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PHASE 1 HYDROGEOLOGIC INVESTIGATION
FEASIBILITY OF
RECOVERING GROUND WATER
IN THE
EAST MESA AREA
IMPERIAL COUNTY, CALIFORNIA
(OUR JOB NO. E-83066)

Mr. Wilson —
You are the office of record for this.
UA GM 14 Feb

By the way, have you seen this before and do you have a previous copy?
UA

LeROY CRANDALL AND ASSOCIATES consulting geotechnical engineers. 711 n. alvarado st.. los angeles, ca 90026. (213) 413-3550

November 30, 1983

Six Agency Committee
c/o 107 South Broadway, Suite 8103
Los Angeles, California 90012

(Our Job No. E-83066)

Attention: Mr. Myron B. Holburt

Gentlemen:

Our report entitled, "Phase I Hydrogeologic Investigation, Feasibility of Recovering Ground Water in the East Mesa Area, Imperial County, California" is herewith submitted. This report supersedes our preliminary report dated September, 1983.

The Phase I hydrogeologic investigation indicates that a program of recovering ground water in the study area is considered feasible. Based on our study, we estimate that 700,000 acre-feet of water has been added to ground water in storage through seepage loss from canals. Additional studies are recommended to verify the validity of recovering water, particularly from a water quality standpoint.

Respectfully submitted,

LeROY CRANDALL AND ASSOCIATES

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PHASE 1 HYDROGEOLOGIC INVESTIGATION

FEASIBILITY OF

RECOVERING GROUND WATER

IN THE

EAST MESA AREA

IMPERIAL COUNTY, CALIFORNIA

Prepared for

Six Agency Committee

by

LeRoy Crandall and Associates

TABLE OF CONTENTS

Text

TABLE OF CONTENTS

(Continued)

TABLE OF CONTENTS
(CONTINUED)

Tables

Plates

APPENDIX

INTRODUCTION

This report presents the results of our Phase I investigation undertaken to evaluate the feasibility of recovering ground water in the East Mesa Area in Imperial County, California. A sizable ground water basin underlies the East Mesa Area. Seepage losses from the unlined All American and Coachella Canals have contributed additional water to ground water in storage in the area. Water recovered from the East Mesa Area could be utilized in Southern California directly or indirectly through tradeoffs.

SCOPE OF WORK

Phase I of the investigation was authorized on March 17, 1983, and included the collection and analyses of basic available data to:

1) Develop an estimate of the volume of ground water in storage (resulting from seepage losses).

2) Determine the direction(s) of ground water movement.

3) Determine the ground water quality.

4) Determine the potential annual pumpage and duration in years of such pumpage.

5) Determine if a second phase was appropriate to include drilling and testing of a series of water wells to obtain the formation parameters of transmissivity and storativity.

The first phase of the investigation included the following tasks:

Task 1 — Acquisition of geologic and soil maps covering the area of interest.

Task 2 — Field reconnaissance of study area to refine available map information.

Task 3 Collection of logs of water wells, geothermal wells, and other subsurface data.

Task 4 Collection and study of historic ground water level measurements at water wells.

Task 5 Collection and study of chemical analyses of surface and ground waters.

Task 6 The development of information on owners of existing wells and estimates of pumpage.

Task 7 Preparation of a report presenting the findings of the first phase of study and recommendations for the next phase.

Our professional services have been performed using that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geologists practicing in this or similar localities. No other warranty, expressed or implied, is made as to the professional advice included in this report.

LOCATION AND DESCRIPTION OF STUDY AREA

The study area is shown on Plate 1, Location Map of Study Area. The study area is located in the East Mesa Area of the Imperial Valley in the extreme southeastern part of California, about 35 miles southeast of the Salton Sea. The study area is bordered by the Algodones Sand Hills on the east, the East Highline Canal on the west, the California-Mexico Border on the south, and a line parallel to and approximately 10 miles north of the border. The study area forms an irregular rectangular-shaped area encompassing approximately 184 square miles.

The All American Canal lies in the southern portion of the study area, near the international border. Approximately 21 miles of this canal traverses east-west through the study area. The new lined Goachella Canal, completed in 1980, extends about 12 miles northwesterly from the All American Canal in the eastern portion of the study area. The lined canal is located just east of the old unlined canal. The East Highline Canal extends northerly from the All American Canal along the western border of the study area. About 11 miles of East Highline Canal borders the study area.

Interstate 8 extends southeasterly from the East Highline Canal to Midway Well, and then east to the Algodones Sand Hills. Most of the area is undeveloped and unpopulated, except for some residences at Gordon's Well in the southeastern corner of the area. Two small experimental farms are located along the All American Canal in the south-central portion of the study area. Farm No. 1 and Farm No. 2 are located south and north, respectively, of the All American Canal. About three square miles in the southwestern corner of the study area are in cultivation. This area includes some laterals (small canals) for irrigation and drains for return irrigation water. Other small areas in the East Mesa Area have been or will be put into cultivation. The northwestern corner of the study area includes a portion of the Holtville Airfield and the Imperial Valley Sanitarium. Geothermal power facilities are present near the western border of the study area north of Interstate 8.

PREVIOUS WORK

The investigation began on March 21, 1983, with the review of in-house information, including published and unpublished literature (see bibliography). A working base map of well locations and data available for each well was prepared to assist in our analyses. The unpublished data included information from our prior transmission line study along the Border.

Some information on the East Mesa Area was obtained from the Colorado River Board, in the form of transcripts of the Colorado River litigation, Arizona vs. California. The Board also provided some Bureau of Reclamation data on logs of recent borings adjacent to the All American Canal. A geohydrological study of the aquifers of the Mexicali Valley and San Luis Mesa, Mexico, also provided by the Board, was briefly reviewed.

Microfiche data on water quality were obtained from the Department of Water Resources in Sacramento, and 14 well logs were obtained from their Los Angeles office. Water level data were not available on microfiche for the study area. Files at the California Division of Oil and Gas were reviewed at the Long Beach and El Centro offices, but very little information was obtained.

The most abundant and useful data, with respect to water levels, have come from reviewing data at the Imperial Irrigation District's office in Imperial. Hydrographs from 334 observation wells in the study area were obtained from the District. Current readings (1978-1983) were plotted to update some of the District's hydrographs. Many of the hydrographs included graphic well logs; descriptive well logs were also obtained for many of the wells. Some data were also obtained from the

District on the amount of seepage loss from the All American Canal from about 1942 to 1969.

A brief reconnaissance of the area was also performed along Interstate 8. Data in the Yuma office of the U.S. Bureau of Reclamation were also reviewed. Data obtained from the Bureau included some well logs, piezometer data, and a ground water hydrology report of the Coachella Canal area.

HISTORY OF CANALS AND SEEPAGE

The All American and Coachella Canals were constructed as unlined canals in the 1940's to bring Colorado River water to the Imperial and Coachella Valleys. Construction on the All American Canal began in August, 1934 and was completed in late 1940. Water was delivered to the East Highline Canal in October, 1940. In February 1942 the All American Canal became the sole means of diverting Colorado River water to Imperial Valley. Four power drops were constructed on the All American Canal between the Coachella Canal and the East Highline Canal. Depth (below ground surface) varies between 5 to 28 feet, 4 to 39 feet, and 10 to 15 feet for the All American, Coachella, and East Highline Canals, respectively. At Drop 4 on the All American Canal, the canal is about 50 feet deep locally.

The Coachella Canal was completed in 1948 and began diverting water from the All American Canal (at Drop 1) to the Coachella Valley. Initial water delivery began in 1944 along the completed portion of the canal in the study area. Soon after construction of both canals, leakage from the unlined canals began creating mounds of ground water beneath the canals. To prevent significant loss of water from the Coachella Canal, the U. S. Bureau of Reclamation reconstructed the first 49 miles of the canal with a new concrete-lined canal. The new canal is located east of the older reach and was completed in late 1980.

PHYSIOGRAPHY

GENERAL

The study area within East Mesa is located in Imperial Valley within the Salton Trough Physiographic Province. The valley is bordered by the Salton Sea on the northwest, the Chocolate Mountains on the northeast, the Peninsular Range on the southwest and the Andrade Mesa and Mexicali Valley on the southeast, which is contiguous with the Imperial Valley. The study area is bordered on the west by relatively flat-lying cultivated land of the central Imperial Valley within the high water lines of prehistoric Lake Cahuilla. Bordering the study area on the east are the Algodones Sand Hills, comprising a northwesterly trending zone of sand dunes about five to six miles wide. Some of the ridges of the dunes are as much as 300 feet above the surface of the mesa (Loeltz, et al, 1975).

TOPOGRAPHY

The surface of East Mesa slopes west-southwestward at approximately 6 to 12 feet per mile. Elevations of the study area vary from about 160 feet at the base of the Sand Hills to about 25 to 35 feet adjacent to the East Highline Canal. The surface itself is typically covered by thin, irregularly-shaped sheets of windblown sand generally less than 20 feet thick (Loeltz, et al, 1975). Individual dunes are often oriented northwest-southeast. The predominant form of vegetation in the study area consists of scattered creosote bushes. The All American Canal crosses East Mesa at an elevation of about 160 feet on the east to about 40 feet on the west.

DRAINAGE

Drainage in the study area is essentially internal. The very low annual rainfall, the soil moisture deficiency, the consumptive use of desert vegetation, and the irregular shaped surface of the mesa (formed by the dune sands) precludes any major drainage. Some minor drainage channels are present in the western portion of the area. No major drainage channels enter or traverse the study area.

GEOLOGY

REGIONAL GEOLOGY

East Mesa is located in Imperial Valley within the southern portion of the Salton Trough. This trough is a structural and topographic depression, representing a sediment-filled fault block bounded generally by the San Jacinto Fault System on the west and the San Andreas Fault System on the east. Faults present within the trough on or near its axis include the Imperial, Brawley and Calipatria Faults. The Imperial Fault is located in the Central Imperial Valley west of the study area. The latter two faults cross the western portion of the study area.

Sediments infilling the trough include Holocene through Eocene non-marine and marine deposits and sedimentary rocks, up to 20,000 feet thick, overlying a basement complex of pre-Tertiary plutonic and metamorphic rocks. Depth to basement complex beneath the study area varies from about 10,000 feet on the east to over 20,000 feet in the western portion.

LOCAL GEOLOGY

General

The general geology of the study area is shown on Plate 2, General Geologic Map. Cross sections of the study area are presented on Plates 3 through 6, Cross Sections A-A' through F-F'. The geology of the study area consists of a gently sloping alluvial surface mantled with thin veneers of Holocene wind blown sand. Underlying these sands, as well as exposed at the surface, are Quaternary deltaic and lacustrine deposits.

The study area is bounded on the east by the inferred west branch of the Sand Hills Fault, part of the San Andreas Fault System. The Calipatria and Brawley Faults traverse the western and southwestern portions of the mesa.

Three high heat flow or geothermal anomalies have been recognized in the study area. The Mesa Anomaly is located northeast of the intersection of the East Highline Canal and Interstate 8, and is the main anomaly in the study area. The Border Anomaly is located north of and parallel to Interstate 8 in Range 18 East SBBM. The Dunes Anomaly is located in the eastern portion of the area in Section 33 in T15S, R19E between the Sand Hills Fault (west branch) and the Coachella Canal. These anomalies are not discussed further in the report.

Deltaic Deposits

Shallow subsurface deposits underlying the study area predominantly represent river deltaic sediments of the Colorado River delta. Available logs for wells in the study area indicate that the deltaic sediments predominantly consist of fine to coarse sand, locally silty, clayey or gravelly, and silt, clay, and silty clay. There appears to be somewhat of a coarse to fine gradation in grain size from east to west beneath the study area. Many of the gravels encountered in wells along the east side are probably fanglomerate deposits derived from the Chocolate Mountains to the northeast. The log for a well in the Dunes Geothermal Anomaly Area indicates that the deltaic deposits are at least 2,000 feet thick. About 800 feet of the deposits in this area have been hydrothermally altered.

Along the All American Canal, logs from several U.S. Bureau of Reclamation test holes indicate that the upper 100 feet of sediments are mainly light brown, poorly graded, loose, fine to medium grained sand with some gravel and with about 5% fines. Some of these gravels are rounded, indicating a fluvial source. The sand contains layers or lenses of a brown, fat, soft to stiff clay varying in thickness from about 2 feet to 24 feet. Logs from some of our shallow borings drilled near the canal for a prior transmission line study indicate that some of the sand and clay is silty.

Lacustrine Deposits

The deposits of Lake Cahuilla consist of a tan and grey fossiliferous lacustrine clay, silt, and some fine grained sand. Some evaporite deposits are also present. The Cahuilla Lake beds are present at the surface in the westernmost portion of the study area, adjacent to the East Highline Canal. These deposits are intercolated in the subsurface with the deltaic deposits to the east.

Windblown Sand Deposits

The windblown sand deposits overlie the deltaic and lacustrine deposits throughout much of the study area. These sands are well sorted and fine to medium grained and are 20 feet or less in thickness. These sand deposits appear to be stabilized or semi-stabilized by native vegetation. Plate 2 shows the general distribution of the sand deposits. Additional smaller bodies of sand deposits are present in the area but are not shown on the map.

Subsurface Distribution of Deposits

Cross sections A-A' through F-F' depict the subsurface deposits beneath the study area. Most of the wells for which logs are available in the area are 50 feet or less in depth. In addition, most of the logs are not of sufficient detail and/or the materials are not distinctive enough to allow correlation of deposits over any great distance. Deltaic deposits are generally interfingering, discontinuous and lenticular. Some of the thicker layers of clay in the well logs may represent lake bed deposits which may be continuous over some distance.

From east to west, the deposits generally grade from gravel to sand to clay. However, the lack of sufficient deeper information and the lack of distinctive deposits prevent any widespread correlations from being made.

Faulting

Two major faults have been recognized in the study area: the Calipatria Fault and the Brawley Fault. Both faults trend northwest-southeast through the west and southwest portions of East Mesa, as shown on Plate 2. The faults are reported to have a right lateral as well as a vertical component of movement. The Calipatria Fault is downthrown on the northeast side, whereas the Brawley Fault is downthrown on the southwest side as shown on Plate 4. Basement complex rocks are indicated to have a vertical separation of about 7,000 feet across the Calipatria Fault in East Mesa. Only minor offset of basement rocks is indicated for the Brawley Fault.

Our analysis of ground water data indicates that there is a disparity in water levels across both faults. This is discussed further in the following Hydrogeology Section of the report.

A well in the Dunes Geothermal Anomaly Area encountered a fault in the deltaic deposits at a depth of 500 feet. The fault consisted of a three-foot-thick zone of fault gouge (clay). No other information is available on this fault.

HYDROGEOLOGY

WELL INVENTORY

Data obtained from the Imperial Irrigation District (I.I.D.) and from various sources listed in the bibliography indicate at least 500 wells in the study area, as shown on Plate 7, Well Location Map. These wells include observation wells, test holes, geothermal wells and test holes, temperature wells, petroleum exploration wells and test holes, and water wells.

Available data on each well were tabulated, including information on the well number, owner or user, year drilled, depth, type of rig used to drill the well, diameter of casing, pump type and power (if any), yield, well use, measuring point above ground surface, elevation of ground surface, and the interval of perforations in the casing. Useful data are not available for many of the wells. The tabulated data have not been included in the report but are available for review in our supporting data files.

The wells are numbered in accordance with the system used by the California Department of Water Resources and the U.S. Geological Survey. Table 1 should be referred to for an explanation of the numbering system. A last digit number has been added to the wells to provide reference to data in the supporting data files. In some instances, only the approximate location of the well within a subdivision or a portion of the section is known. Lack of sufficient location data for some

Table 1

Well Numbering System

Well numbers in the text and on plates are in accordance with the numbers applied to wells by the California Department of Water Resources and the U. S. Geological Survey in California. These numbers indicate the township, range, section and position of the well within each section according to 40-acre tracts. For example, for well 16S/18E-21R1, the first number and letter indicate the township (16 south), the second number and letter indicate the range (18 east), the number following the hyphen indicates the section, and the following letter and number indicate the 40-acre subdivision of the section and which well within that subdivision. The 40-acre subdivisions within a section are as follows:

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

*NOTE: All well numbers are referenced to the San Bernardino Baseline & Meridian wells may have resulted in their duplication on the map. Some discrepancies in well numbering are also present in literature. Well locations were not field checked during this phase of the study.

Of the approximately 500 wells in the study area, four are deep oil or gas wells or exploratory drill holes (15S/17E-27F1, 16S/17E-16Q2, 16S/18E-27E and 17S/19E-5J1). About 32 wells are geothermal wells or drill holes, and 12 are water wells (15S/16E-36E1, 15S/17E-19E1, and 19E2, 16S/17E-16Q1, 16S/19E-36P1 and 36P2, 16S/19E-36Q1, Q2 and Q3, 16S/20E-32R1, 17S/17E-3C1, and 17S/18E-4H4). The petroleum and geothermal wells are indicated on Plate 7 by special symbols. Wells 17S/18E-4A3 and 17S/17E-3C1 are used by I.I.D. to supply cooling water for turbine generators at Drops 3 and 4, respectively (Loeltz, et al, 1975). Well 4A3 has a pump set at 76 feet (below ground surface) with a pump capacity of 272 gpm. The pump in Well 3C1 is set at 96 feet and is usually pumping 350 gpm. No records of pumpage for the water wells in the area were made available. A brief field reconnaissance and a fly over of the area indicate that present pumpage is a small quantity.

In addition, one well (17S/20E-4D1) is a pilot production well constructed by the U.S. Bureau of Reclamation (U.S.B.R.). The remaining wells are observation wells, temperature wells, and test holes, including 10 test holes drilled by our firm in 1980 for a transmission line study. Many of the wells in the area are either abandoned, destroyed, or unused.

Most of the wells in the study area have been used to monitor changes in water levels due to canal seepage. The majority of the wells are located in the southern portion of the area, near or in the vicinity of the All American Canal. The remaining non-observation wells are concentrated primarily in the Mesa and Dunes geothermal anomaly areas discussed earlier.

Nearly all of the wells have been drilled since late 1940. Approximately 66 observation wells were drilled in the early 1940's. Three wells (17S/17E-3C, 17S/18E-4B, and 17S/19E-4F) were reportedly drilled in 1936, and Gordon's Well (16S/19E-36P1) was drilled in or prior to 1933. Gray's Well may also have been drilled during the 1930's. Several other wells may also have been drilled in the 1930's. Midway Well was drilled in or near 1940. Five water wells (16S/19E-36Q1, 36Q2 and 36Q3 and 15S/16E-19E1 and 19E2) have been drilled in the early 1980's, and several test holes have been drilled by the U.S.B.R. in the late 1970's and early 1980's as well. The U.S.B.R. recently completed drilling 16 additional observation wells along or near the All American Canal between Drop 1 and the East Highland Canal in May and June, 1983. These wells are not shown on the plates.

Depths are available for approximately 435 wells. Most of these wells, about 306 wells or 70 percent, are 60 feet or less in depth. Most of these were constructed for the monitoring of water levels and seepage from the All American Canal. About 79 wells or drill holes (17%) are between depths of 100 and 600 feet, six wells or drill holes are between depths of 6,000 and 8,200 feet, and one well (oil or gas Well 15S/17E-27F1) was drilled to a depth of 10,624 feet. The deeper wells are associated with geothermal and oil/gas exploration.

Well casings vary from 1 to 18 inches in diameter, but 2 inches is the most common diameter for the observation wells. The interval of perforations in the casing is unknown for many wells. Some of the wells have only well points attached to the bottom of the casing.

Information on water levels in the study area was obtained from water level measurements by the I.I.D. over a period of 30 to 40 years for about 334 wells. The I.I.D. began recording water levels between 1940 and 1950 and have continued the observations until the present time. Measurements began from about 1940 to 1942 for 62 wells. 246 observation wells were constructed in the study area sometime between 1947 and 1950. Most of the measurements, therefore, began during this time period.

Periodic measurements of the wells continued until 1976 when measurements were discontinued for 174 wells. Prior to 1976, 59 wells had been dropped from their monitoring program for various reasons. Measurements have continued for 101 wells into the early 1980's. Continuous water level measurements are available for only 17 wells from the early 1940's to the early 1980's.

The I.I.D. maintained hydrographs on water levels until 1976. Following 1976, they continued with the monitoring of the remaining wells but have not updated the hydrographs. We have taken I.I.D.'s measurements and updated the hydrographs for the years 1977 to 1983. A total of 334 hydrographs were obtained and reviewed for this study. Representative hydrographs of the study area in relation to the All American Canal are presented on Plates 10 through 13, Hydrographs.

OCCURRENCE AND MOVEMENT OF GROUND WATER

Occurrence

Ground water in the study area occurs in the alluvial (deltaic) deposits beneath the mesa. Based on data from logs in the area, ground water occurs in sand and gravel deposits under unconfined conditions throughout most of the area. Under such a condition, precipitation on the surface or seepage from the canal can percolate unimpeded to the water table. Ground water then moves under the force of gravity according to the slope of the water table.

Little information is available on the continuity and areal extent of clay beds beneath East Mesa. In some areas, clay beds may prevent the downward migration of water to the water table, causing semi-perched or perched conditions. These conditions could particularly be found in the western portion of East Mesa, in association with the Cahuilla Lake beds.

Ground water occurs under both confined and unconfined conditions immediately east of the East Highline Canal, as well as to the west. Clay beds between overlying and underlying permeable layers restricts the free hydraulic connection between the aquifers. Ground water under confined conditions is moving under pressure caused by a difference in head between the recharge area and the discharge area.

The hydrograph of Well 15S/18E-16P1 indicates that the U. S. Bureau of Reclamation noted "some artesian action" in the northwestern portion of the study area. The U.S.B.R. also recorded rises in water levels of between 0.2 and 3.0 feet during drilling of Wells 15S/17E-31P1 and 34R1, 15S/18E-18R1, 16S/17E-16R1, 16S/18E-17R1, and 16S/19E-17R1. This suggests that confined or semi-confined conditions may occur locally in the study area.

Water Levels

Water level information in the study area prior to construction of the All American Canal is limited to two wells, Gray's Well (1933?) and Gordon's Well (1933), and two test holes, 17S/17E-36 (1936) and 17S/18E-4B (1936) at Drops 4 and 3, respectively. This information consists of a single measurement for the year indicated. With the commencement of water deliveries in 1940, additional water wells and observation wells were constructed. Hydrograph data are available for 19 wells beginning in 1940. The areal distribution is very poor, however, with 16 of those wells located west of Drop 4.

By 1942, the number of wells with data had increased to 59 with fair areal coverage. Plate 8, Ground Water Contour Map, October 1942, illustrates the ground water surface after about two years of operation of the canal. Water levels along the canal had already shown a rise of about 2 feet at Gordon's Well between 1933 and 1940. The depth to the ground water surface at Gordon's Well was 83 feet in 1940. The depth to ground water in 1942 was about 70 feet at Gordon's Well, 55 feet at

Midway Well, 34 feet east of the Calipatria Fault and 10 feet at the East Highland Canal. Preconstruction All American Canal ground water level data are not available for determining the rise in other wells between 1940 and 1942.

The ground water contours indicate that ground water movement was generally west-northwest in the northern portion of the mesa. In the southern portion of the area (north of the canal), ground water movement was more northwesterly, suggesting that canal seepage was already having an affect on the ground water table. Cross Sections C-C' through F-F' (Plates 5 and 6) indicate a broad, subtle mound of water below the All American Canal. This also suggests that seepage was already having an affect on the water table. Data are not available for the area south of the All American Canal, east of Drop 4. Limited water levels in the vicinity of Drop 4 suggest that ground water may be moving southwesterly towards the Border. Water level data south of the Border were unavailable for the 1940's, and therefore ground water movement into Mexico could not be demonstrated. However, water level data for 1939 in the Andrade Mesa and Mexicali Valley indicate that, prior to the operation of the All American Canal, ground water movement was westerly.

The water level data indicate that the Calipatria Fault in the study area acts as a partial barrier to ground water movement at depth. There appears to be as much as 10 feet in disparity across the fault in 1942, with the water level lower on the west side.

The Brawley Fault may also act as a barrier to ground water movement, but to a lesser degree. Water level data suggest that there may be a difference of two feet or less.

Ground water movement north of canal between the Calipatria and Brawley Faults is to the northwest, parallel to the faults, and is possibly due to the barrier effects of the faults.

The average hydraulic gradient during 1942 from Gordon's Well in the southeast to the Holtville airfield in the northwest is about 0.0007 ($3\frac{1}{2}$ ft/mile).

The elevation of the ground water surface during October 1982 is presented on Plate 9, Ground Water Contour Map, October, 1982. Depth to ground water along either side of the All American Canal varied from about 9 feet near Gordon's Well to about one foot near Midway well.

Contours of 1982 water levels indicate that ground water movement was west-northwest for most of the study area north of the canal and towards Mexico south of the All American Canal. Data on water levels are very limited along the north border of the area, but ground water movement here appears to be southwesterly and westerly, away from the Coachella Canal.

The effects of canal seepage on the water table are clearly evident on the 1982 contour map (Plate 9). The contours suggest a ridge or mound of water beneath the canal. Ground water is moving northerly on the north side of the canal and southerly towards and into Mexico on the south side of the canal.

The ground water ridge is separated by a trough in the area between Drop 1 and 2. This trough in the surface of the water table extends both to the south (to the border), as well as to the north and the east (about one mile north of Gordon's well). The 1942 levels do not indicate a low at this location, although data here are very sparse. The water level elevations indicate that ground water movement is from east to west north of Gordon's Well and then south beneath the canal into Mexico, as shown on Plate 9. A reasonable interpretation of the data would suggest a buried river or stream channel with a higher transmissibility than surrounding deposits. This channel would allow water to drain relatively faster from this area. A fault cannot be ruled out, and a northeast trending vegetation lineament is present at this location. However, the channel interpretation is the most reasonable. The channel may represent a former channel of the ancestral Colorado River.

West of Drop 2 on the All American Canal the depth to ground water varies from 0 to 25 feet. Probably most of the ground water is in direct hydraulic connection with water in the canal (above the invert of the canal). Water levels in observation wells along the canal suggest direct connection since 1951. East of Drop 2, the depth to ground water varies from about 15 to 40 feet. The saturated zone is probably below the invert of the canal and not in direct connection with canal water except near Gordon's Well.

The 1982 water level data and contouring do not indicate any definitive offset of the water table which could be attributable to the Calipatria and Brawley Faults. If the faults do affect the 1982 levels, the disparity would be less than a few feet.

The average hydraulic gradient for 1982 levels from east to west is about 0.001 (5 ft/mile). This is slightly greater (steeper) than the average gradient that existed in 1942 levels.

Water levels for 1976, in a prior study by others, clearly indicate that ground water movement south of the Border is south-southwesterly in Andrade Mesa and Mexicali Valley. Therefore, the effects of canal seepage in the U. S. are clearly evident south of the Border.

Water Levels Near East Highline Canal

Water level data between 1962 to 1976 near the East Highline Canal suggest that some seepage had occurred from this canal. 1982 water levels (Plate 9) do not indicate significant seepage from the canal. However, some seepage is suggested as shown by the water level profile on Cross Sections G-G' and I-I' (Plates 15 and 16). Cross Section G-G' indicates a five-foot rise in the water level near the canal, south of Interstate 8. Cross Sections I-I' and J-J' suggest a much broader but subtle rise in the water level east of the canal. The canal appears to intercept the water table in each of the sections. As shown on Plate 15, the water level actually declines immediately adjacent to the canal in Section H-H', which may indicate that the canal is acting as a drain.

Water Level Fluctuations

A review of the available hydrographs indicates that cyclic fluctuations occur annually in wells adjacent to and in the vicinity of the All American and East Highline Canals. The cyclic fluctuations are greatest at the canals and decrease in magnitude in both directions away from the canals. The fluctuations may be the result of an increase in seepage loss in response to an increase in inflow in the canals.

Three main areas of water level fluctuations occur along the All American Canal: 1) just west of Drop 1, 2) between Gordon's Well and Drop 3, and 3) just east of Drop 4. In each of these areas, the annual cyclic fluctuation is nine feet or greater. The greatest fluctuation in 1949 was 17 feet and occurs at two localities: about 1/2 mile east of Drop 2, and at Experimental Farm No. 2 (north of Drop 2). The fluctuations do not occur in wells farther away from the canals. By 1975, the magnitude of these yearly fluctuations decreased to a maximum of seven feet.

The seasonal variation in water surface elevations in the All American Canal is reported to be about two feet or less (I.I.D. hydrographs). This change in head may be sufficient to increase the rate of seepage into underlying materials to cause the greater change in the water table. In addition, irrigation in the past may also have contributed locally to the seasonal rise in water levels.

The rise first occurs adjacent to the canals and then proceeds away from the canal in both directions. The rise initially begins sometime between January and March. The initial rise in water levels appears to have occurred first at Drop 3 in January, at Drop 2 in February, and in March at Drop 1. The rise spreads slowly away from the canal at Drops 3 and 4, but rapidly in the vicinity of Experimental Farm No. 2, between Farm No. 2 and Drop 1, and to a much lesser extent at Farm No. 1. There is an abrupt change in the rate of the rise west of Drop 4, where it rapidly progresses laterally. This may be related to farming and irrigation in this area and possibly to a perched water table condition as well.

Other Water Level Changes

The hydrographs indicate that other changes have occurred in water levels in localized areas in the study area. Hydrographs for wells in the vicinity of Experimental Farm No. 2 indicate that water levels declined about 4 to 8 feet in March 1971 with apparently no recovery through 1976. Water levels also declined about 3 to 8 feet in 1957 for wells south of the All American Canal between Drop No. 1 and Drop No. 2. This is close to the time that seepage from the canal was at a minimum. Water levels did not rise again until either 1960 or 1973, but they did rise a similar amount. Repeated seepage losses were high in 1960 and 1974 but not to the extent of the losses in earlier years. The fluctuation in water levels again might be related to the amount of inflow and/or seepage in the All American Canal. Several other declines in water levels are also recorded on the hydrographs; some of these appear to be local and rapid. For example, the hydrograph for Well 17S/19E-4B1 indicates that the water level rose 10.8 feet from January 1949 to February 1949. A note on the hydrograph suggests that this rise might be a clay seal breaking under a head of water.

The effects of lining the Coachella Canal, essentially stopping seepage, is clearly evident in hydrographs. The closest wells to the canal with current hydrographs (15S/18E-16P1, 16S/19E-5M1, and 16S/19E-25R1), about 1/2 to 1 mile away, record a steady decline in the water level of five feet from late 1980 to early 1983. Several wells up to three miles away record a decline of 1 to 2½ feet.

TOTAL RISE IN WATER LEVELS FROM CANAL SEEPAGE

General History of Rise in Water Levels

As previously discussed, initial delivery of water to the All American Canal began in 1940. By October of 1940, water was being diverted to the East Highline Canal. By February 1942, water in the canal was the sole source of water for Imperial Valley. Water was apparently flowing in the Coachella Canal in 1944 according to data by Loeltz and Leake (1977).

Water level data for 1940 are available for only 19 wells. However, the first measurements of water levels for 13 of these wells began in December 1940, after canal operation had already begun. Water levels are available for only six wells (16S/16E-24R1, 16S/17E-29P1, 16S/17E-34R1, 16S/18E-35P1, 16S/19E-36P1 and 17S/16E-1R1) prior to December 1940. The earliest measurements, however, for any of these wells is August, 1940. Examination of the hydrographs of these wells (all but 24R1 and 29P1 are shown on Plate 10) indicate that an initial rise in water levels, presumably due to canal seepage (All American Canal), may have occurred either sometime during or before the period August to November, 1940. This initial rise varied from about 4 to 23 feet, but then levelled off in 1941 or 1942. The rate of rise was as much as 19 feet in one year for Well 16S/17E-34R1. Water levels then remained approximately level for about 2½ to 3½ years until 1944 or 1945.

Beginning in mid 1944 or early to mid 1945, a second sustained rise in water levels for wells along the All American Canal near Drop 4 and westward to the East Highline Canal is then recorded in the hydrographs. This rise occurred prior to the increase in seepage losses from the All American Canal which began in 1946 (Plates 10 through 13). The increase in seepage loss occurred at approximately the same time as a slight increase of inflow in the All American Canal in 1946. This rise also occurred in four wells (15S/18E-14R1 and 16P1, and 16S/19E-5M1 and 17R1) along or near the Coachella Canal in 1945 as a result of inflow in, and seepage loss from, the Coachella Canal beginning in 1944. Therefore, the second rise may reflect the combined contribution of seepage losses from both canals to water levels along the All American Canal. Water levels from this sustained rise eventually rose as much as 30 to 40 feet in wells 15S/16E-14R1 and 16P1, 16S/18E-35P1, and 16S/19E-5M1.

Notes on several hydrographs indicate that the U.S. Bureau of Reclamation raised the level at a pond at Drop 4 (All American Canal) one foot on July 10, 1944. This corresponds to the beginning of the sustained rise in levels observed on the hydrographs. This may also have contributed in part to the rise in water levels locally. The exact location and the dimensions of this pond are not indicated on the hydrographs.

The maximum annual rate of rise varied from less than one foot per year to as much as 10 feet per year. Some of the rises are very rapid and abrupt on the hydrographs. For example, water levels in wells in Sections 30, 31, and 32 in T16S, R19E rose 15 feet or more in a time span of only a few months in 1948. This time corresponds to the maximum rate of increase in seepage loss.

According to the U.S. Bureau of Reclamation (1974), the rate of rise of the water table during early use of the Coachella Canal in East Mesa varied from 4.3 feet/year in the southeast to 0.25 feet/year on the west.

This rise along the canal alignment appears to have then stabilized in the late 1940's or early 1950's, as shown on Plate 10. This indicates that the mound of ground water beneath the All American Canal may have reached the canal bottom. The gradient of the mound adjacent to the canal then decreased and seepage decreased. Water levels along the canal either remained relatively level or only gradually increased thereafter. Water levels then rose progressively farther northward in the study area until they stabilized around 1965 (Plate 13).

Water Level Rise, 1940-1982

Only a few water level measurements are available for wells during the period of initial service of the canal in 1940 to full service in 1942. Data are available for only 19 wells for the years 1940 to 1942. Of this total, 16 wells are located between the East Highline Canal and Drop 4. The remaining three wells with data, all along the All American Canal, are Gordon's Well (16S/19E-36P1), Midway Well (16S/18E-35P1), and Well 16S/17E-34R1.

Data for these three wells indicate a significant rise in the water levels between 1940 and 1942. For Gordon's Well, Midway Well, and Well 16S/17E-34R1, the rise in levels was about 13 feet, 10 feet, and 19 feet, respectively. If this is combined with the rise between 1942 and 1982, the total rise near Gordon's Well, Midway Well, and Well 16S/17E-34R1 has been about 60 feet, 53 feet, and 48 feet, respectively, since 1940. Water levels along the canal reached their highest elevation in about 1951 with essentially no change since that time.

The rise in water levels progressed gradually away from the canal. The data indicates that levels for wells three miles away from the All American Canal began to rise about 1942 and reach their peak between 1960 and 1965. Water levels six and nine miles north also had their maximum rate of increase prior to 1965.

The total rise in the ground water table between 1942 and 1982, as a result of canal seepage, is presented on Plate 14, Rise in Water Levels, 1942-1982. The rise in the ground water table was determined from the hydrograph data and from overlaying the 1942 and 1982 contour maps.

Analysis of the data indicates that the greatest increase in water levels occurs in three general areas. The most extensive area is the northeastern quarter of the study area where water levels have risen between 40 and 45 feet. This is apparently the result of significant seepage from the unlined Coachella Canal. The second area is in the vicinity of Midway Well and Experimental Farm No. 2 where water levels have risen 40 feet or more. The maximum rise in this area is about 49 feet. The third and smallest area occurs at the junction of the Coachella and All American Canals. Although the area is small, between 50 and 58 feet of rise has been recorded.

The rise in water levels decreases generally from about 40 feet in the east to less than 10 feet near the East Highline Canal.

SPECIFIC YIELD

General

The specific yield of deposits underlying East Mesa was determined utilizing the method developed by the California Division of Water Resources (1934). As a result of their studies, which consisted of experimental work (laboratory testing) and subsurface studies, the Department assigned values of specific yield for various types of alluvial deposits. These values varied from 3% for clay to 26% for coarse and medium sand and fine gravel.

Well logs for about 43 wells in the study area were selected and reviewed to estimate the average specific yield of deposits at that locality. Thicknesses of the different materials were determined and then multiplied by the assigned specific yield values. The average specific yield was then calculated for the entire column of deposits.

Calculated Specific Yield

The average specific yields calculated from selected well logs are shown on Plate 14. The range of values varied from about 4% near the East Highline Canal to 25% which occurs mainly along or adjacent to the Coachella and All American Canals. The average specific yield for shallow deposits in the study area is 21%. The lower specific yields are primarily found in the westernmost portion of the area. The low specific yields here are associated with the Cahuilla lake beds (clay) at the surface and in the subsurface and varied from 4 to 11%. The high values are found elsewhere in the study area and are associated with the coarser grained deposits.

POTENTIALLY RECOVERABLE WATER

Computation of the "potentially recoverable" ground water in the study area was based on the change in storage methodology utilized by the State Water Rights Board in the San Fernando Reference (City of Los Angeles vs. City of San Fernando, 1962). This methodology is incorporated into the following discussion. We have defined "potentially recoverable" as that total increase in quantity of water in storage which could theoretically be pumped given a sufficient areal coverage of wells. The actual amount recoverable would depend on a number of factors, including the number of wells, location of wells, the rate and duration of pumping, and when the pumping is initiated.

The deposits underlying the study area are discontinuous and vary from locality to locality. In addition, the accuracy and quantity of water level and specific yield data vary between localities. Therefore, the quantity of potentially recoverable ground water was determined for separate subareas rather than for the whole area. The summation of the potentially recoverable water for these subareas is then equal to the total for the East Mesa study area.

Eleven subareas were selected and are shown on Plate 14. These areas were primarily selected on the basis of similar specific yields. The potentially recoverable water was determined by multiplying the area (determined by using a planimeter) of a comparable rise in the water level by the total average rise in the water level within that specific area. These values were than summed for the subarea. The resulting volume of saturated deposits was then multiplied by the average weighted specific yield for the subarea. This value of specific yield is shown on Plate 14 and in Table 2.

The total "potentially recoverable" water from the study area based on increases in ground water storage since 1942 is approximately 700,000 acre-feet. This could be considered a minimum recoverable amount as this calculation does not consider the increase in ground water storage between 1940 and 1942 along the All American Canal.

Table 2
Summary of Potentially Recoverable Water

Subarea	Average Specific Yield (%)	Potentially Recoverable Water (A-F)
1	8	4,000
2	22	25,000
3	21	43,000
4	24	51,000
5	25	82,000
6	20	77,000
7	23	116,000
8	19	48,000
9	18	59,000
10	25	118,000
11	18	77,000
	Total	700,000 A.F.

AQUIFER CHARACTERISTICS

Previous Well Tests

Pumping test data are available for 11 wells in the study area. Most of this information is from studies performed by the U. S. Geological Survey (Loeltz, et al, 1975). One well, 15S/18E-15M1, just north of the study area, was included to provide information in that general area. The available test data are presented in Table 3 and include: well number, date of test, type of test, interval tested, yield, drawdown, specific capacity, and computed transmissibility. Not all of this information is available for each well. This table also includes estimated yields for two artesian wells (15S/16E-36E1 and 16S/16E-1B1) located near the East Highline Canal, west of the Calipatria Fault.

Of the 11 wells with aquifer test data, nine are located along or near the All American Canal (17S/17E-3C1, 4A3 and 4B1; 16S/18E-32R2; 16S/19E-32G2, and 36P1; 16S/20E-31K1; and 17S/20E-4D1), two are located along the unlined Coachella Canal (15S/18E-15M1 and 16S/19E-11D1), and one well (15S/17E-19E1) is located at the Holtville Airfield. Well 16S/20E-31K1 is also adjacent to the Coachella Canal, near Drop 1. Wells 16S/18E-32R2 and 17S/18E-4A3 and 4B1, are located next to Drop 3, and Well 17S/17E-3C1 is adjacent to Drop 4. Aquifer test data are not available for the central portion of the study area.

Table 3

Aquifer Tests

Well No.	Date of Test	Type of Test	Interval Tested (ft.)	Yield (gpm)	Drawdown (ft.)	Specific Capacity (gpm/ft.)	Computed Transmissibility (gpd/ft.)
15S/16E-36E1	1961			50 (A)			
15S/17E-19E1	8-3-81		240-360	3,000			
15S/18E-15M1	5-10-63	R	309-894	1,000	20	50	220,000
	"	D	309-894	1,000	20	50	220,000
~~16S/16E-1B1~~	~~1974~~			~~100(A)~~			
16S/18E-32R2	6-29-64	R	140-630	900	21	43	140,000
16S/19E-11D1	5-14-63	R	300-610	990	24	41	240,000
-32G2	1958		69-273	1,350			
-36P1	1951		100-228	80	105	0.8	
16S/20E-31K1	5-2-62	R	340-410 510-520	1,035	12	85	850,000
	5-2-62	D	340-410 510-520	1,035	12	85	880,000
	1964			1,000			
17S/17E-3C1	1948		0-105	600			
17S/18E-4A3	1952		179-195	130			
-4B2	1967		38-60 65-86 122-173	280	44	6.4	
17S/20E-4D1	12-2-76	D	212-293 323-544	2,875	55	52	

D = Drawdown
R = Recovery
A = Artiesian, yield estimated

Data for two wells (15S/18E-15M1 and 16S/20E-31K1) are for both drawdown and recovery tests, two wells (16S/18E-32R2 and 16S/19E-11D1) have data from recovery tests and data for Well 17S/20E-4D1 were for a drawdown test. It is not known what type of tests were conducted for the remaining wells. Most of the intervals tested were between depths of about 100 feet and 630 feet. The deepest interval tested was to a depth of 894 feet, and the shallowest was less than 100 feet.

Well Yields

Seven of the wells had yields between 600 and 1,350 gpm, three had yields between 80 and 280 gpm, and two had yields of 2,875 and 3,000 gpm. The wells adjacent to the Coachella Canal had yields of between 990 and 1,035 gpm. Yields for wells along the All American Canal vary from 80 gpm to 2,875 gpm. The two artesian wells adjacent to the East Highline Canal had flows estimated at 50 and 100 gpm. The well near Holtville Airfield is reported to have a pumping yield of 3,000 gpm.

In general, yields of 900 gpm or more are associated with depths greater than approximately 200 feet. Yields have been as much as 600 gpm in the upper 100 feet (near Drop 4).

Drawdown and Specific Capacity

Drawdowns and specific capacities are available for seven wells: 15S/18E-15M1, 16S/18E-32R2, 16S/19E-11D1, 16S/19E-36P1, 16S/20E-31K1, 17S/18E-4B2, and 17S/20E-4D1. Drawdown for the wells varies from 12 feet to 105 feet. Drawdown in wells along the Coachella Canal varied from 12 to 24 feet, whereas drawdown in wells along the American Canal varied from 12 feet to 105 feet (16S/20E-36P1). Specific capacities for the wells varied from 0.8 (16S/20E-36P1) to 85 gpm/ft. The latter specific capacity is for Well 16S/20E-31K1 located at the junction of the Coachella and All American Canals.

The specific capacities along the east side of the study area appear to be higher. In addition, the higher specific capacities of 41 to 85 gpm/ft appear to be associated with depths greater than 200 feet. The lower specific capacities of 0.8 and 6.4 gpm/ft appear to be associated with depths less than 200 feet.

Transmissibility

Values of transmissibility computed by Loeltz, et al (1975) are available for four wells: 15S/18E-15M1 (220,000 gpd/ft), 16S/18E-32R2 (140,000 gpd/ft), 16S/19E-11D1 (240,000 gpd/ft) and 16S/20E-31K1 (850,000 gpd/ft). These data are shown on Plate 14. Transmissibility appears to be higher in the eastern portion of the area along the Coachella Canal. Transmissibility appears to decrease in a westerly or southwesterly direction, as well as in a northwesterly direction.

Ground water contours for 1942 and 1982 indicate that water levels are flatter in the eastern portion of the area compared to the western portion. This would indicate higher transmissibilities in the eastern portion of East Mesa and is supported by the geologic data (coarse grained deposits).

GROUND WATER QUALITY

General

The analysis of water quality in the study area is based on existing data from various sources, but primarily from the California Department of Water Resources and the U. S. Geological Survey. Water quality analyses are available for about 104 wells; 47 of these wells were used to prepare stiff diagrams on Plate 17, Chemical Character of Ground Water. A representative water quality analysis for water from the Colorado River (Imperial Dam) is also shown for comparison. Three of the wells (15S/16E-23F1, 16S/16E-1M1, and 16S/16E-35F1) are located just west of the East Highline Canal, but are shown to provide better coverage and to illustrate the variability in chemical character. Water quality of selected wells is also shown on Plate 18, Water Quality Zone A, 85-160 Feet, and on Plate 19, Water Quality Zone B, 0-85 Feet. These two zones were differentiated based on water quality data versus depth. These data are summarized in Table 4. Water quality data used on Plates 17 through 19 are presented in Appendix A. Data for the remaining wells in the study area are not provided in the appendix, but are available for review in our supporting data files.

Table 4

Water Quality Zone A vs. Zone B

	Zone A (85 to 160 Feet)		Zone B (0 to 85 Feet)	
Chemical Character	Sodium Chloride	15 wells	Sodium Chloride	13 wells
	Sodium Sulphate	3 wells	Sodium Sulphate	10 wells
	Sodium Bicarbonate	0	Sodium Bicarbonate	6 wells
pH	Range: 7.4 - 8.6	(17 wells)	Range: 4.3 - 11.2	(27 wells)
	Common: 7.4 - 8.6		Common: 6.9 - 9.0	
	4.3 - 6.4	0	4.3 - 6.4	4 wells
	6.5 - 7.5	1 well	6.5 - 7.5	5 wells
	7.6 - 8.6	16 wells	7.6 - 8.6	11 wells
	8.7 - 9.7	0	8.7 - 9.7	3 wells
	9.8 - 11.2	0	9.8 - 11.2	4 wells
TDS (ppm)	Range: 589 - 2860	(17 wells)	Range: 250 - 2620	(27 wells)
	Common: 750 - 995	9 wells	Common: 434 - 787	16 wells
	589	1 well	250	1 well
	1270	1 well	882 - 1413	7 wells
	1710 - 2860	6 wells	1750 - 2620	3 wells
	7112	(1 well)*	7151	(1 well)*
F (ppm)	Range: 0.2 - 1.4	(10 wells)	Range: 0.1 - 1.6	(22 wells)
	1.9	(1 well)*	3.0	(1 well)*
B	0.26 and 0.46	(2 wells)	0.41	(1 well)

* not included in the range of values.

Chemical Character

General. Plate 17 shows the chemical character of ground water in the study area. The information includes the cation and anion concentrations in milliequivalents per liter, date sampled, depth sampled or total depth of well, and the electrical conductance in micromhos/cm. The overall areal distribution of water quality data appears good at first glance. However, a variability is apparent in the chemical character as illustrated by the stiff diagrams. Because of this variability, the water quality data were examined with respect to the intervals sampled to determine if there were different zones of water quality. The analysis concentrated on data with known specific depths from which samples were collected and analyzed.

Examination of the available data indicates that sample intervals are known for only 45 wells. Analyses of the water quality and perforation data indicate that ground water in East Mesa can be differentiated into water quality zone A (85 to 160 feet depth) and a water quality zone B (0 to 85 feet depth). The two zones can be differentiated on the basis of chemical character, pH, total dissolved solids (TDS), and interval perforated as shown on Plates 18 and 19. Information was available for five other wells which had very large sample intervals or multiple intervals in these zones. These data were excluded to reduce the possibility of analyzing data in which mixing of ground water in the different intervals may have occurred. Two wells (16S/17E-23R1 and 16S/18E-23A2), however, were used which had two separate, small sampling intervals. Some data are available for a few wells with sample intervals varying in depth from 300 feet to greater than 7,600 feet. However, the study concentrated on only the upper several hundred feet which was considered important to the present study. Water quality zone A could extend deeper, but no specific information is available between 160 and 300 feet. The deeper data (greater than 300 feet) with information on interval perforated are not included in this report, but are available for review in our supporting data files.

Water Quality Zone A (85-160 feet). Data are available for only 18 wells in Zone A. Two of these wells (16S/17E-23R1 and 16S/17E-23A1) have multiple perforated zones. Areal distribution of the data is poor and is mainly concentrated in or adjacent to Township 16S, Range 18E, and near the eastern border of the study area. Two wells (16S/19E-36P1 and 17S/18E-4K) are located adjacent to the All American Canal. One well, 15S/18E-15K1, is located just north of the study area but has been included to provide coverage in that area.

The general mineral analyses indicate that ground water in Zone A is sodium chloride in chemical character. This zone is likely more representative of the natural ground water in the study area, and probably has not been affected much by seepage of the canals. The effects of the canal are, however, apparent in four wells, as the chemical character of the water was sodium sulphate. The chemical character of the Colorado River water and water in the canals is also sodium sulphate. Two of these wells (15S/18E-15K1 and 16S/19E-2N1) are located along the old Coachella Canal (in service from 1948 to 1980), one (16S/19E-36P1) is located along the All American Canal, and one (16S/16E-12Q1) is located along the East Highline Canal. Another analyses of water from the latter well, however, indicated a chemical character of sodium chloride.

Data on pH for Zone A are available for 17 wells. This information indicates that the pH for ground water between depths of 85 and 160 feet varies from 7.4 to 8.6, similar to Colorado River water. Some inconsistency in the data is indicated as two different analyses performed on water samples from Well 16S/18E-17R yielded markedly different pH values of 8.0 and 2.6. (The 2.6 value may be a typographical error in the basic data).

The total dissolved solids (TDS) content of ground water in Zone A commonly varies from 750 to 995 ppm, based on water samples for nine wells. The TDS of a Colorado River water sample in 1981 was 798 ppm for comparison. The lowest TDS content analyzed was 589 ppm in Well 17S/18E-4K near the All American Canal. Some wells had TDS contents varying from 1,710 to 2,860 ppm. One well, located in the northwestern corner of the study area, 15S/16E-24G1, had a very high TDS content of 7,112 ppm. This may be either related to evaporites associated with the Cahuilla Lake beds or possibly associated with brine from geothermal water.

Again, some inconsistency in the data is present. Analyses of water from Well 16S/16E-12Q1, adjacent to the East Highline Canal indicated a TDS content of 817 ppm for one sample and 2,549 ppm for the second sample. Water samples from Well 16S/18E-17R, in the central portion of the study area, had a TDS of 892 ppm in one sample and a TDS of 1,960 ppm in the second sample.

The fluoride and boron concentrations are available for 11 and 2 wells, respectively, in the study area. The concentration of fluoride varies from 0.2 to 1.4 ppm. One well, 15S/19E-28N, located in the northeastern portion of East Mesa, had a fluoride concentration of 1.9 ppm. The boron concentration for Wells 16S/18E-23A2 and 16S/19E-36P1 (Gordon's Well near the All American Canal) were 0.46 ppm and 0.26 ppm, respectively.

Water Quality Zone B (0-85 Feet). Data are available for 29 wells in Zone B, including two wells which were also sampled in Zone A. Although the distribution of data along the All American Canal is very good (21 wells), the areal distribution for the study area is very poor. Four wells (15S/18E-15K2 and 26R1, 16S/19E-5J and 15Q1) are located along or near the old Coachella Canal (in service from 1948 to 1980), one of which is north of the study area. This well, 15S/18E-15K2, has been included to provide additional coverage. Two wells (15S/16E-24G2 and 36E1) are located along or near the East Highline Canal. There are only two wells (16S/17E-23R1 and 16S/18E-23A2) with water quality information located in the central portion of the study area.

The general mineral analyses indicate that ground water in the Zone B is sodium chloride (13 wells) and sodium sulphate (10 wells) in chemical character. Eight of the wells with sodium sulphate water are located along the All American Canal and two are located along the Coachella Canal. The data clearly indicate the effect of canal seepage (sodium sulphate water) on ground water along the canal. Six wells, five along the All American Canal and one along the East Highline Canal are sodium bicarbonate in chemical character.

Data on pH for Zone B are available for 27 wells. This information indicates that ground water between depths of 0 and 85 feet is more variable in pH in contrast to the deeper Zone A. The pH is commonly 6.9 to 9.0. The Colorado River water in the canal has a pH of 8.1 for comparison. The range in pH values is greater in Zone B than the deeper Zone A, varying from as acidic as 4.3 to as basic as 11.2. The pH of 4.3 occurs in Well 16S/17E-23R1, located adjacent to Interstate 8. Ground water in six wells adjacent to the All American Canal is also slightly acidic, varying from 5.8 to 6.9. The rather high basic water occurs in five wells along the All American Canal and varies from pH 9.0 to 11.2.

The total dissolved solids content of ground water in the shallow zone, available for 28 wells, commonly varies from 434 to 787 ppm, and is lower than the deeper Zone A. The range of values is the same as along the All American Canal. Colorado River water in the All American Canal has a TDS of about 798. The lowest TDS analyzed was

250 ppm in Well 17S/19E-6B1, along the All American Canal. TDS values as high as 2,080 ppm occur along the canal.

Two wells, 15S/16E-24G2 and 16S/17E-23R1, had TDS contents as high as 7,151 and 2,620 ppm, respectively. The TDS content in Well 15S/16E-24G2 is equivalent to the content in an adjacent well (24G1) in the deeper zone. This high value may be due to evaporites in the Cahuilla lake beds, brine from geothermal waters, or mixing of waters in the two zones during sampling. The deeper well (24G1) may also be perforated in the shallow zone as well.

The fluoride and boron concentrations are available for 23 wells and one well, respectively. The fluoride concentration varies from 0.1 ppm to 1.6 ppm, comparable to Zone A, but the concentration in Well 15S/16E-36E1, adjacent to the East Highline Canal, was high (3.0 ppm). The boron concentration for Well 16S/18E-23A2 was 0.41 ppm, comparable to the very limited information available for Zone A.

HYDROLOGY

WATER SUPPLY

The source of water supply to the ground water reservoir in the study area is primarily derived from seepage from the canals. Precipitation is not considered a significant source of recharge in the desert environment. Records of the El Centro Station indicate an average annual rainfall of 2.3 inches. Due to the arid conditions and soil moisture deficiencies, virtually no rainfall would reach the ground water reservoir.

Canal Seepage

The total addition to ground water from canal seepage in the East Mesa study area was estimated from seepage data obtained from the I.I.D., Loeltz, et al (1975), and Loeltz and Leake (1977). Data available for the All American and Coachella Canals were for the periods 1942 to 1976 and 1944 to 1976, respectively. Data between 1944 and 1949 for the Coachella Canal were estimated by Loeltz and Leake (1977) as one-half of the water delivered to the canal. The data were extrapolated (averaged) from 1976 through 1982 for the All American Canal and from 1976 through 1980 for the Coachella Canal. This analysis included data for only those portions of the canals within the study area. Seepage data for the 50 mile length of the Coachella Canal were reduced to 26% of the total for the 12 mile length of the canal in the study area. The seepage losses from the All American and Coachella Canals, and the combined seepage loss, are illustrated on Plates 10 through 13.

The seepage losses for the All American Canal (Drop 1 to East Highline) from 1942 to 1982 were estimated to be 2.2 million acre-feet (AF) and 1.2 million acre-feet for the Coachella Canal from 1944 to 1980.

Water Disposal

Outflow or loss of ground water in the East Mesa study area occurs both at the surface and in the subsurface. Losses which occur at the surface are primarily in areas of shallow ground water along the All American Canal. In these areas, loss is attributed to evapotranspiration by phreatophytes and surface evaporation. Losses which occur in the subsurface are due to subsurface flow to Imperial Valley and to Mexico and to inflow into a portion of the East Highline Canal.

Evapotranspiration

The shallow ground water along the canal has resulted in the growth of phreatophytes along portions of the north and south sides of the All American Canal. Plate 20, Areas of Phreatophyte Growth, All American Canal, shows the location of the phreatophytes and the shallow depths to ground water during 1980. These areas were delineated from a review of photo strip maps flown in 1977 and 1978 along the canal and one landsat photo. Depths to water measurements were obtained from one of our previous studies in the area.

The two principal areas of growth along the canal occur between the East Highline Canal and Drop 4 and midway between Drops 3 and 4. Smaller areas of phreatophytic growth occur near Experimental Farm No. 1, one mile east-southeast of Midway Well, and south of Gordon's Well. Depths to ground water beneath these phreatophytes are 16 to 20 feet or less.

The total consumptive use of water by the phreatophytes along the All American Canal was estimated by determining: 1) the area in acres of phreatophytic growth, and 2) the annual water use by the phreatophytes as a function of depth to ground water. Curves developed by Anderson (1976) were utilized to determine the consumptive use. The total area of phreatophytes along the canal is approximately 2,000 acres. Using the water use curves, based on average depth to water for each area, the total consumptive use by the phreatophytes is approximately 12,600 acre-feet per year.

This estimated amount of consumptive use by phreatophytes is probably conservative. The actual evapotranspiration may be higher than the data used. Observation of the phreatophytic growth during our 1980 transmission line study on the south side of the All American Canal indicated that significant evaporation is occurring from the leaves of the plants as the atmosphere [illegible]

In addition, the actual evaporation may also be higher. Evaporation is occurring from the soils where the water surface is within a few feet of or at the ground surface. At times a power line service road between Drops 3 and 4, about one mile north of the canal has reportedly had several inches of surface water over it.

UNDERFLOW

Loss to Central Imperial Valley

Ground water movement in the study area is generally east to west towards the East Highline Canal and Imperial Valley. Much of the water added to ground water by canal seepage will eventually underflow into the Central Imperial Valley area to the west. The water level data suggest that most of the change in ground water storage occurred prior to 1965 and that contributions to ground water since that time have left the East Mesa area as subsurface flow. This quantity is estimated to be as much as 1 million acre-feet, based on the approximate cumulative losses of the canals from 1965 to 1982 and on the slope of the water table.

The U. S. Bureau of Reclamation (1974) predicted that water levels in East Mesa would decline as much as 40 feet or more (in the northeastern portion) to 5 feet or less (in the southern and western portions) following lining of the Coachella Canal and the resulting reduction in ground water recharge by canal seepage.

Loss to Mexico

With the creation of the ridge of water beneath the All American Canal shortly after operations began, ground water has moved southwards across the border into Mexico. Of the estimated 2.2 million AF of water lost by the All American Canal within the East Mesa study area, approximately one-half (1.1 million AF) or more has been added to storage in Mexico or been used in Mexico. Seepage loss and resulting ground water movement is assumed to be equal for ground water moving both north and south away from the canal. An additional unknown amount may also be moving annually into Mexico through the apparently high permeable zone east of Drop 2.

Limited information was available on water levels in Mexico. An examination of available data suggests that water levels in Mexico may have risen as much as 39 feet south of Drop 1 but with no change near the Alamo Canal between 1939 and 1976.

There is a strong possibility that the pumping of ground water by Mexico in Andrade Mesa and Mexicali Valley would substantially affect water levels in East Mesa. A study of future development of aquifers in Mexicali Valley by the Secretaria de Recurses Hidraulicos (1968) indicates that water levels along the border would decline between 16 to 26 feet near the East Highline Canal, and 23 to 39 feet near Drop 1. This decline would be produced by pumping in areas varying from 6½ to 26 miles southerly of the border. This 1968 study considered a base period between 1957 and 2018. The decline in [illegible] 19 feet in the north-central portion of the East Mesa study area.

A decline as such, produced by pumping in Mexico, could affect conditions in East Mesa, primarily in two ways. A substantial decline would change the gradient of the water table in East Mesa from east to west to northerly to southerly. Ground water movement would then be from East Mesa southwards into Mexico over a much greater area. In addition, ground water level declines beneath the All American Canal could induce additional seepage out of the canal and thus additional seepage loss to Mexico.

Loss to East Highline Canal

A short portion of the East Highline Canal and/or the drain system appears to act as a partial drain for ground water in the northern portion of the East Mesa study area. Ground water movement is generally westerly towards the canal. Water levels in this area are higher than the invert of the canal (Plate 16), and are likely higher than the water surface in the canal. Ground water is therefore intercepted by the canal and/or drains, flows into the canal and then is diverted northwards as well as westward by lateral canals and drains.

Change in Storage

As discussed previously, there has been an increase in ground water storage in the East Mesa area of about 700,000 acre-feet. The greatest increase in storage has occurred along the canals where water levels have risen 40 feet or more.

RECOMMENDATIONS

The data utilized in the preliminary evaluation of the potential for recovery of ground water in the East Mesa Area was not uniformly distributed. Some of the data has questionable validity. In order to extend the area of information to verify the validity of recovering water, particularly from a water quality standpoint, and to provide information necessary for design of a well field, the following recommended program should be considered.

TEST WELLS

A series of test wells and observation wells should be constructed along the All American Canal. We recommend a minimum of four test areas. These would include the area of the probable old river channel near Drop 2, the area near Drop 3, the area near Drop 4 between the Calipatria and Brawley Faults, and the area west of the Brawley Fault. An additional test area where information could be relative to boundary effects of the faults would be adjacent to the Calpatria Fault.

The test wells should be constructed to a depth of about 200 feet. Detailed lithologic logs should be obtained during drilling as well as geophysical logs. The geophysical logs should include resistivity, spontaneous potential and gamma to assist in precisely locating lithologic changes and evaluating vertical water quality variations. Samples of the formation should also be obtained for grain size analysis for use in designing well screen and gravel pack for production wells.

An aquifer test should be performed utilizing the test wells and at least two observation wells at each [illegible] would provide needed information on well yields, aquifer characteristics for use in production well spacing, verification of the quantity of ground water storage, and variability of aquifer characteristics across East Mesa.

WATER QUALITY

The existing water quality data does not have complete areal coverage of the East Mesa Area, and some inconsistencies in the data exists. A program of resampling and analysis of water from available wells in addition to construction of new well points for sampling would provide information on the current water quality.

The quality of the potentially recoverable water could impact the quality of the canal water used for irrigation. The affect of dilution could control the rate of recovery of ground water added to canal water. A study of resulting canal water quality under various pumping schemes should be performed by a geochemist or an agronomist.

CYCLIC FLUCTUATIONS

The cyclic fluctuations of water levels along portions of the canal could indicate increased seepage losses during peak flow in the canal. A more detailed study of this phenomenon should be made to evaluate whether selective lining of the canal embankment could significantly reduce seepage losses.

GROUND WATER MODEL

The East Mesa Area appears to be ideal for use of a ground water model. Sufficient historic water level and seepage loss data appear to be available to verify the model using the aquifer characteristics developed from the test well program. The model could then be used to evaluate the impact of various water level recovery schemes.

CONCLUSIONS

The hydrogeologic investigation of the East Mesa area has included the analysis of well log, hydrograph, well test, and ground water quality data. Analysis of these data indicate the following conclusions.

1. Seepage from the All American and Coachella Canals since their initial operation has been a major contributor to ground water in the study area. Some seepage has occurred from the East Highline Canal, but it apparently is not as significant as the other two canals, due to the presence of lower permeability materials.

2. The total amount of seepage from the All American and Coachella Canals in the study area has been approximately 3.4 million acre-feet.
3. Water levels have been significantly affected by this seepage. Water levels have risen as much as 50 to 58 feet from 1942 to 1982, and as much as 60 feet in one well from 1940 to 1982. The greatest rise in water levels has occurred along the All American Canal where seepage has produced a ground water ridge beneath the canal. Although a ridge is not evident beneath the Coachella Canal, water levels in the northeastern portion of the study area have risen 40 feet or more.
4. Most of the ground water along the All American Canal, from Drop 2 to the East Highline Canal, is above the invert of the canal and is in hydraulic connection with the canal water. East of Drop 2, ground water along the canal is generally below the invert of the canal and is not in direct hydraulic connection with canal water.
5. The movement of ground water is generally from east to west in the study area. Adjacent to the All American Canal, however, ground water movement is northerly to East Mesa as well as southerly towards Mexico.

6. The specific yield of shallow deposits in the study area varies from 25% in many portions of the area to as low as 4% in the west. There appears to be both a general decrease in specific yield and transmissibility from east to west.
7. Based on average specific yields and the rise in water levels, the total "potentially recoverable" water in the study area is estimated to be 700,000 acre-feet.
8. The potential annual pumpage and duration in years of such pumpage was not determined during this study. Many variable factors, such as location of pumpage, number and spacing of pumping wells, impact of pumping on ground water quality, impact on induced canal seepage, and impact of using retrieved water as irrigation water, still need to be addressed first.
9. The Calipatria Fault acts as a barrier or partial barrier to ground water movement. The difference in 1942 water levels on either side of the fault is as much as 10 feet. There is some suggestion that the Brawley Fault may also act as a barrier, but this cannot be documented at this time.

10. A zone of highly permeable deposits is apparently present beneath the All American Canal. This zone locally allows ground water in the study area to move south into Mexico. This zone may be a buried channel of the ancestral Colorado River.

11. Previous well tests in the study area indicate well yields of between 80 and 3,000 gpm. Yields within the upper 200 feet vary from 80 to 600 gpm, and specific capacities varied from 0.6 to [illegible] gpm/ft.

12. Water quality analyses indicate that shallow ground water beneath the study area can be differentiated into two water quality zones (85 - 160 feet and 0 - 85 feet) based on chemical character, pH, and total dissolved solids.

13. The deeper zone is more representative of natural ground water and is primarily sodium chloride in chemical character, has a pH commonly varying from 7.4 to 8.6, and a TDS commonly varying from 750 to 995 ppm. The shallower zone has been affected by canal seepage and is sodium chloride to sulphate in chemical character. The pH commonly varies from 6.9 to 9.0 and the TDS content commonly varies from 434 to 787 ppm.

14. Ground water in the study area has been and is being lost by: underflow into central Imperial Valley and into Mexico, evapotranspiration, and draining into the East Highline Canal.

15. Partial lining of the All American Canal could be expected to have a similar affect on reducing seepage loss and lowering ground water levels as did the lining of the Coachella Canal.

16. Pumping south of the border could increase ground water movement into Mexico, decrease the amount of recoverable water in the study area, and induce additional seepage from the All American Canal.

17. A program of recovering ground water in the study area is considered feasible but should include further study on ground water quality.

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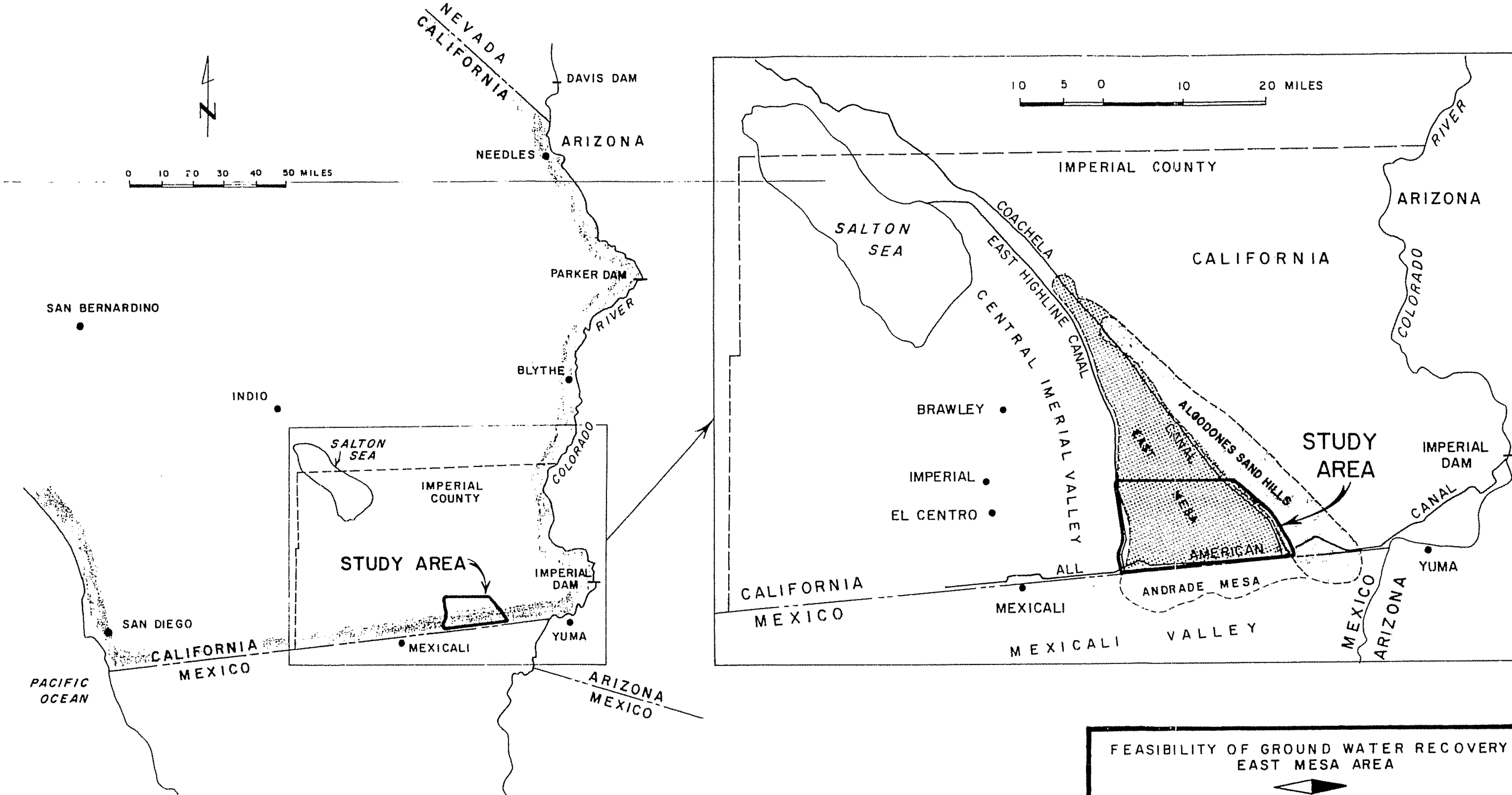
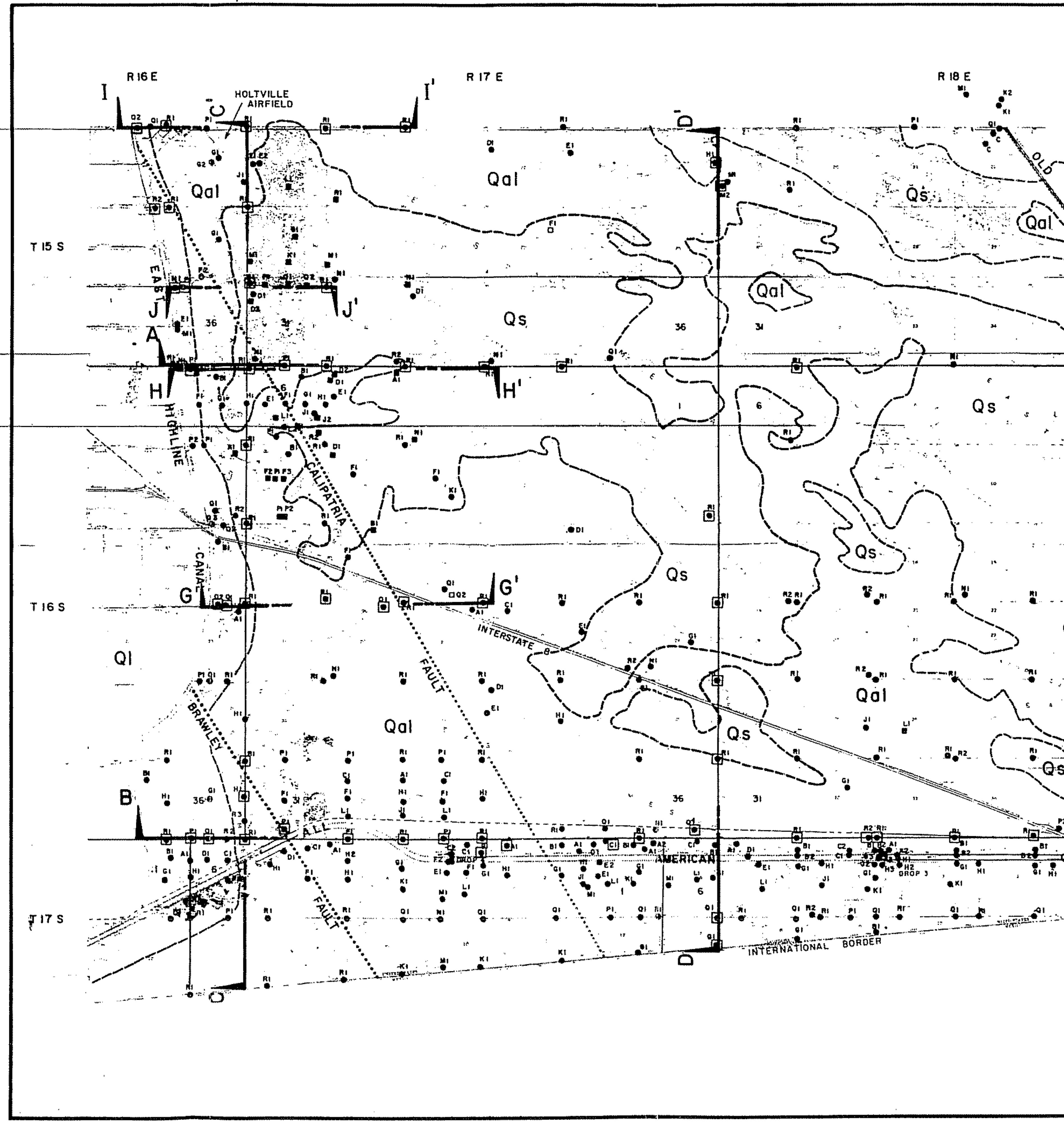


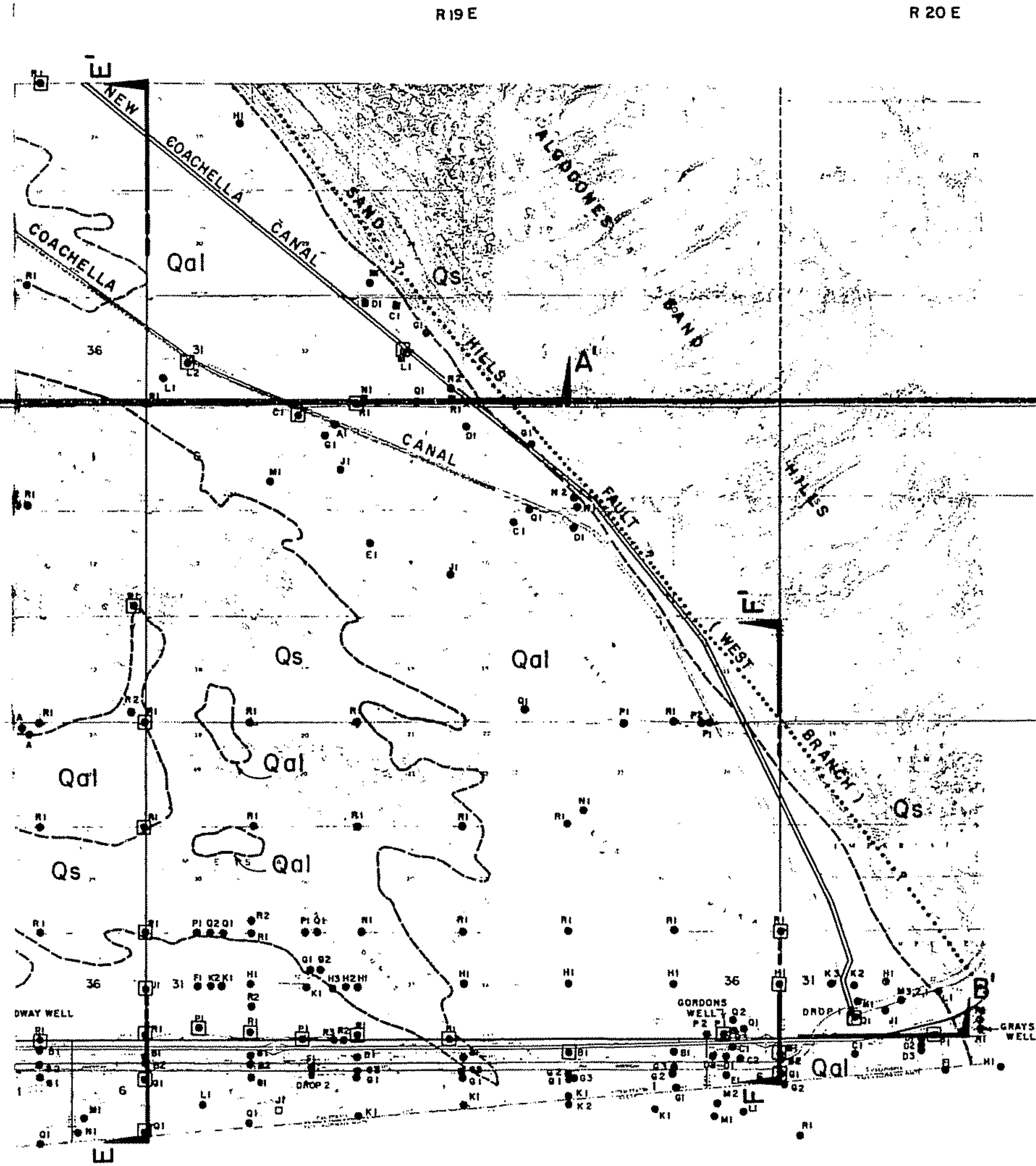
FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

LOCATION MAP OF STUDY AREA

LeROY CRANDALL AND ASSOCIATES | PLATE 1

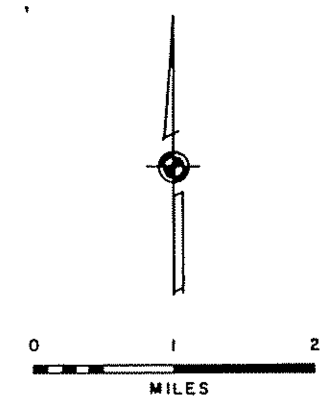
JOB E-83066 DATE 11-23-83 DR. M.G. O.E. CHKD.





EXPLANATION

- ● OBSERVATION WELL, WATER WELL, TEMPERATURE WELL OR TEST HOLE
- ◻ OIL OR GAS WELL OR DRILL HOLE
- ■ GEOTHERMAL WELL OR DRILL HOLE
- K1 WELL, TEST HOLE OR DRILL HOLE NUMBER
- ....?... FAULT, APPROXIMATELY LOCATED OR CONCEALED
- Qal ALLUVIUM - Unconsolidated clay, silt, sand and gravel; Holocene in age
- Qs DUNE SAND - Unconsolidated sand and silty sand; Holocene in age
- Ql LAKE SEDIMENTS - Clay, silt and sand of ancient Lake Cahuilla; Holocene to Pleistocene in age
- ----- GEOLOGIC CONTACT, APPROXIMATELY LOCATED
- A A' CROSS-SECTION
- ⊡ WELL DATA USED IN CROSS SECTIONS

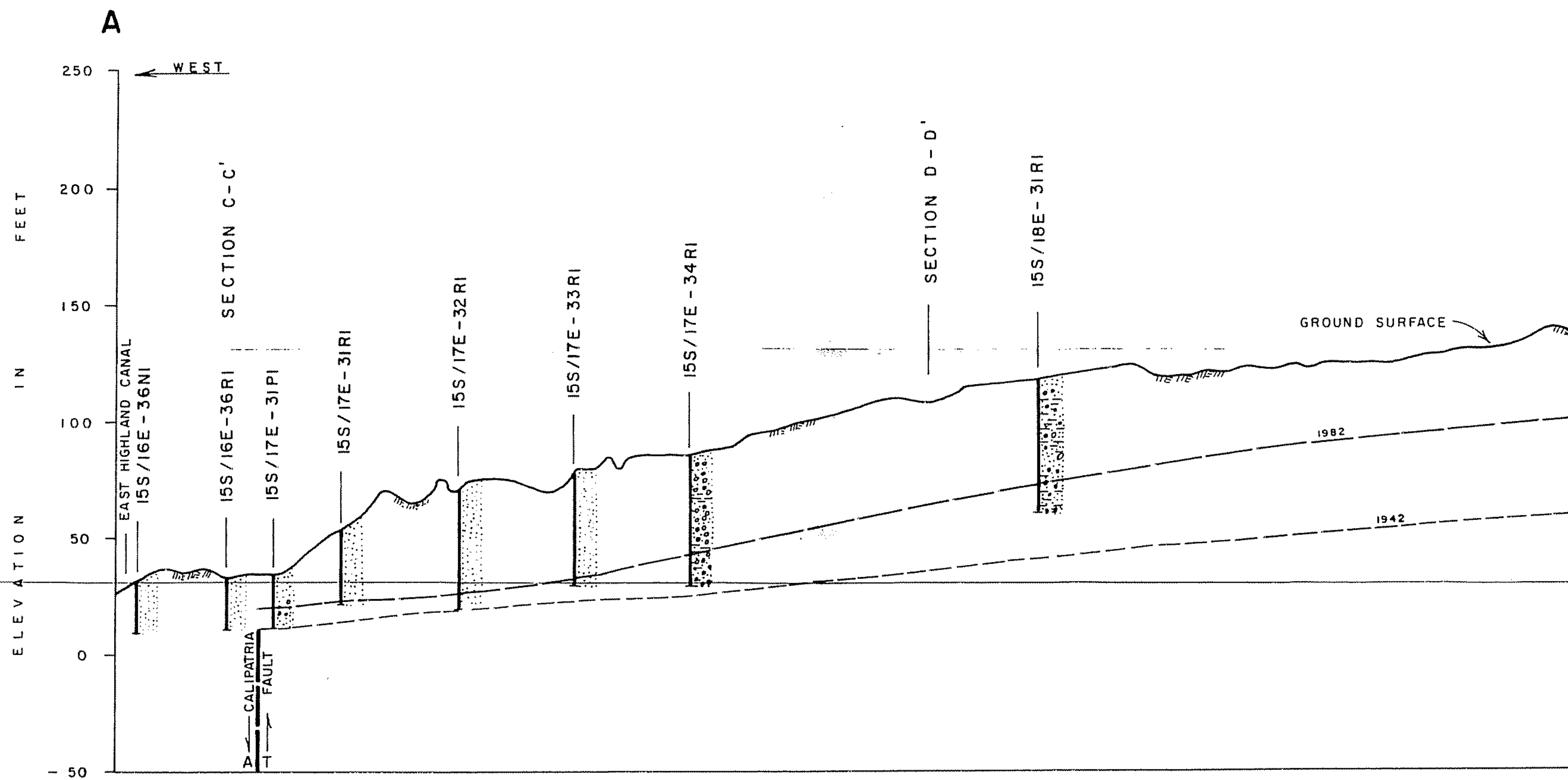


REFERENCES:
BASE MAP PREPARED FROM U S G S $7\frac{1}{2}$ MINUTE TOPOGRAPHIC QUADRANGLES: HOLTVILLE EAST, BONDS CORNER, GLAMIS SW, MIDWAY WELL NW, GLAMIS SE, MIDWAY WELL, CACTUS, AND GRAYS WELL.
GEOLOGY FROM MORTON (1977)

FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

GENERAL GEOLOGIC MAP

LeROY CRANDALL AND ASSOCIATES | PLATE 2



EXPLANATION:

CLAY	
SAND	
SAND AND GRAVEL	
GRAVEL	

16S/19E-5C1 — WELL NUMBER

LOCATION OF WELL

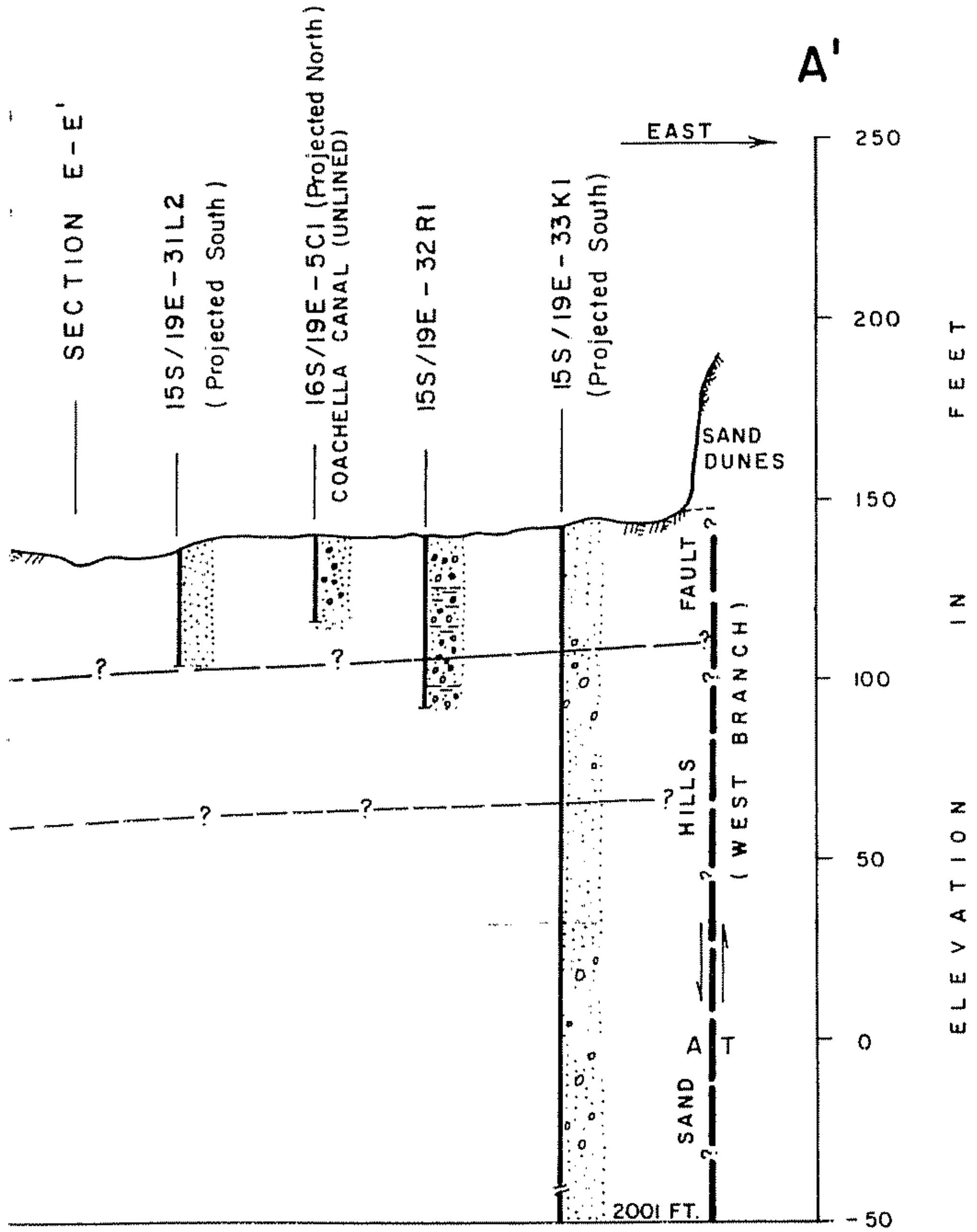
A T — FAULT, SHOWING DIRECTION OF DISPLACEMENT (T=Toward, A=Away)

VERTICAL SCALE 1"= 50'
HORIZONTAL SCALE 1"= 1 MILE

1982 ?___ WATER LEVEL, QUERIED WHERE UNCERTAIN ; 1982 = YEAR

1942 ?— — WATER LEVEL, QUERIED WHERE UNCERTAIN ; 1942 = YEAR

JOB C-83U66 DATE 6-5-85 DR. M.G. O.E. CHKD

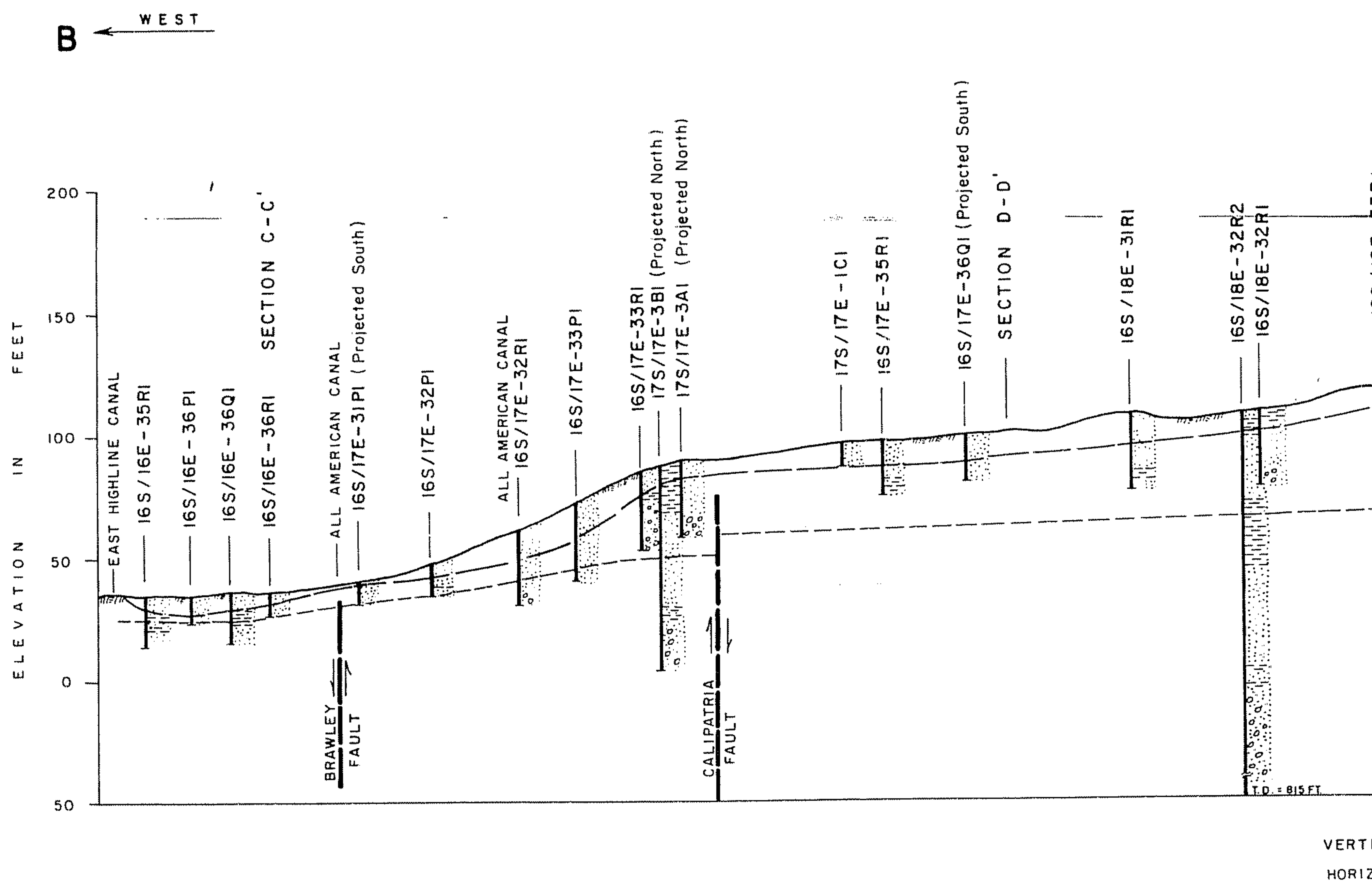


FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

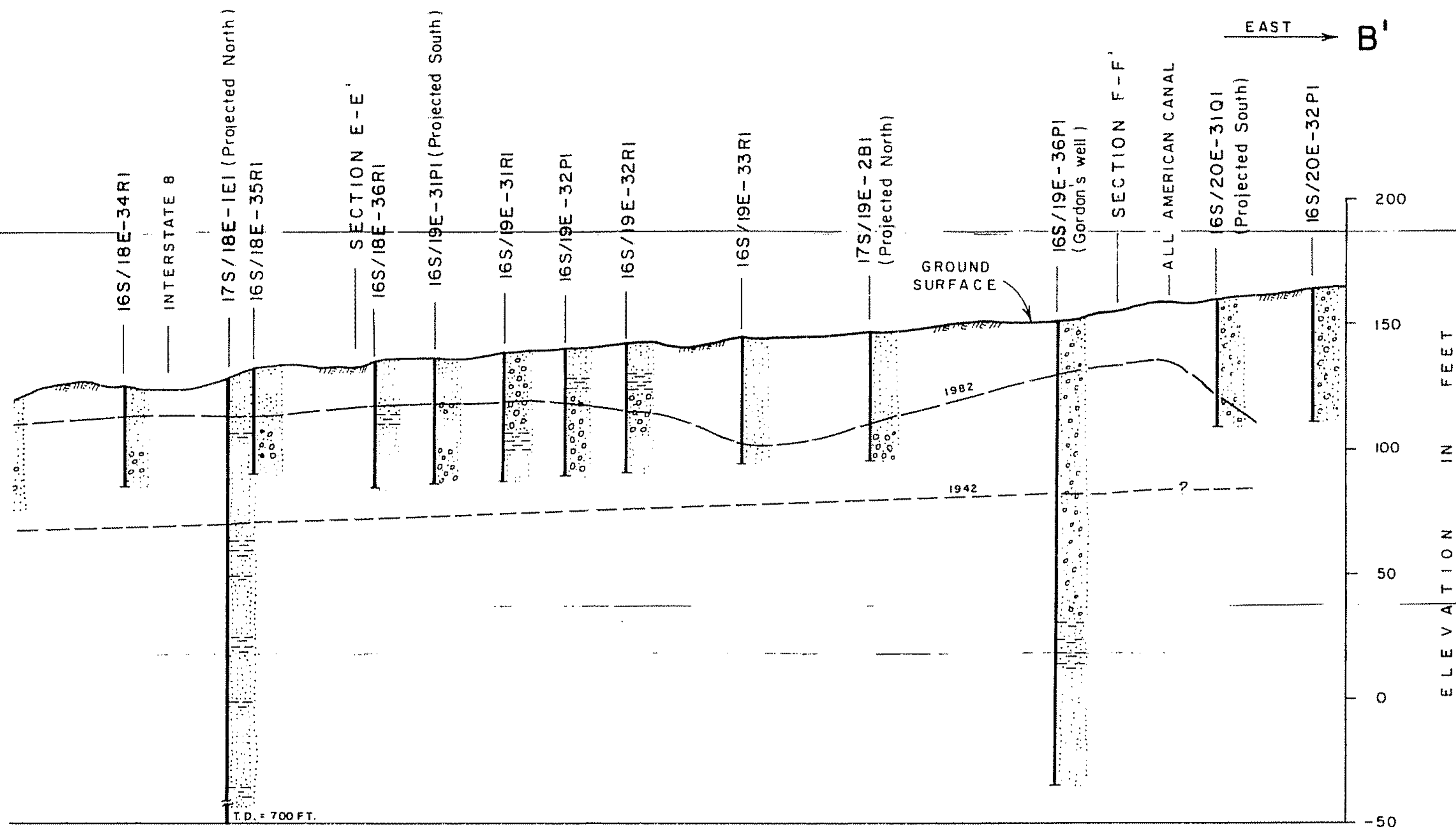
CROSS SECTION A-A'

LeROY CRANDALL AND ASSOCIATES	PLATE 3

JOB E-83066 DATE 11-23-83 DR M.G. CHKD



NOTE. SEE PLATE 3 FOR EXPLANATION



AL SCALE 1" = 50'

TAL SCALE 1" = 1 MILE

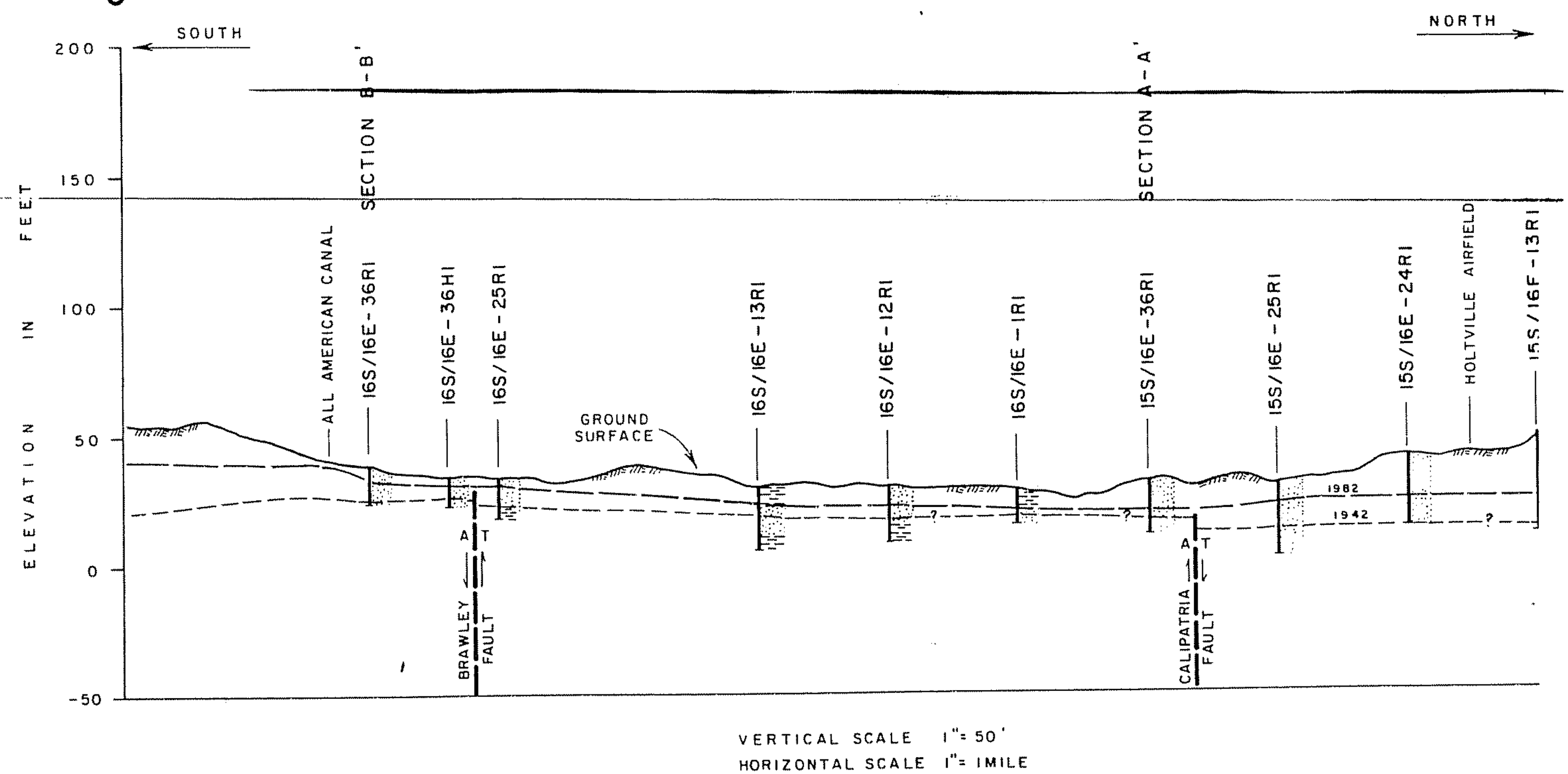
FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

CROSS SECTION B-B'

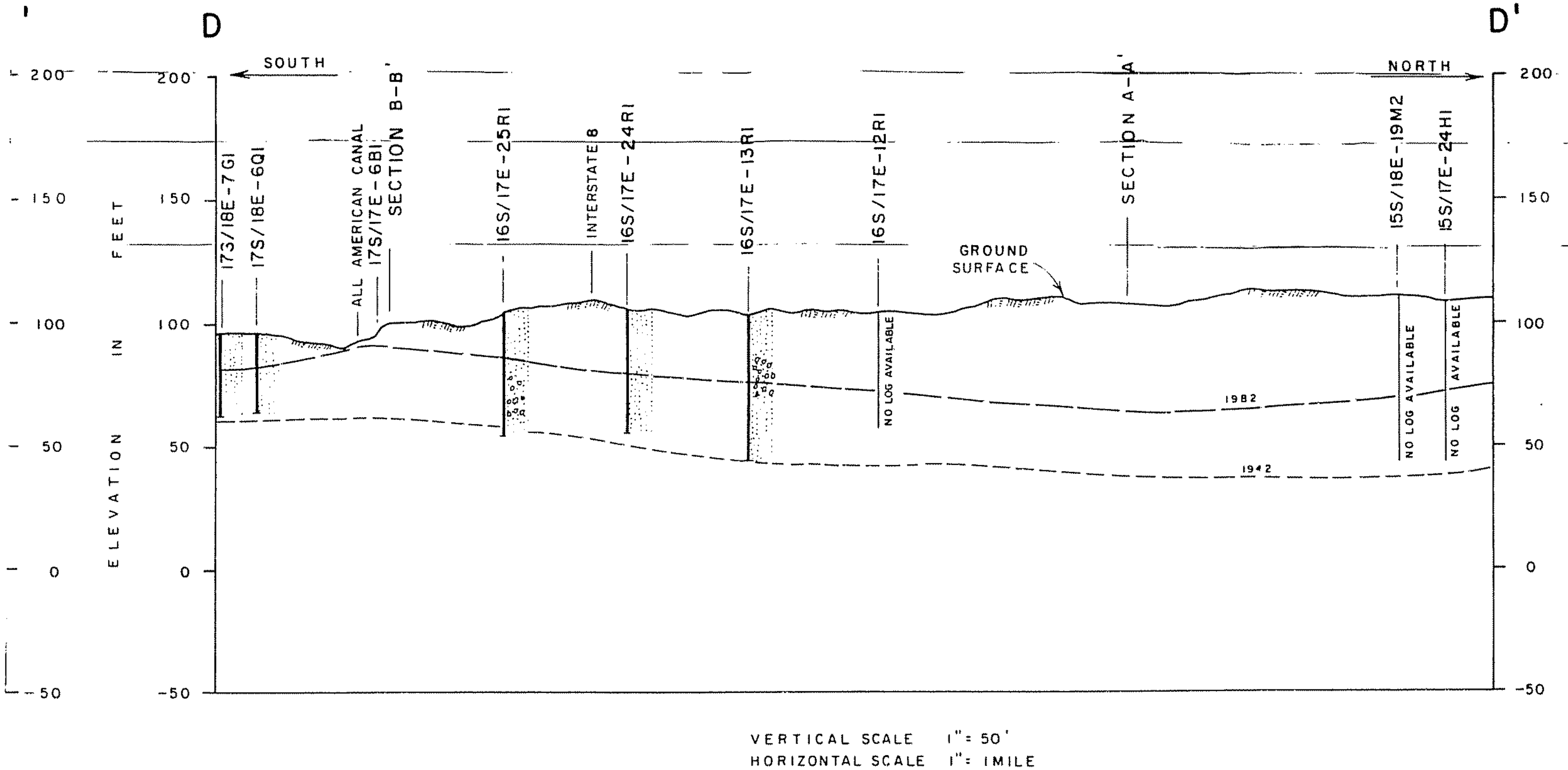
LeROY CRANDALL AND ASSOCIATES | PLATE 4

JOB E-83066 DATE 8-5-83 DR M.G. DF CHKD

C



NOTE SEE PLATE 3 FOR EXPLANATION

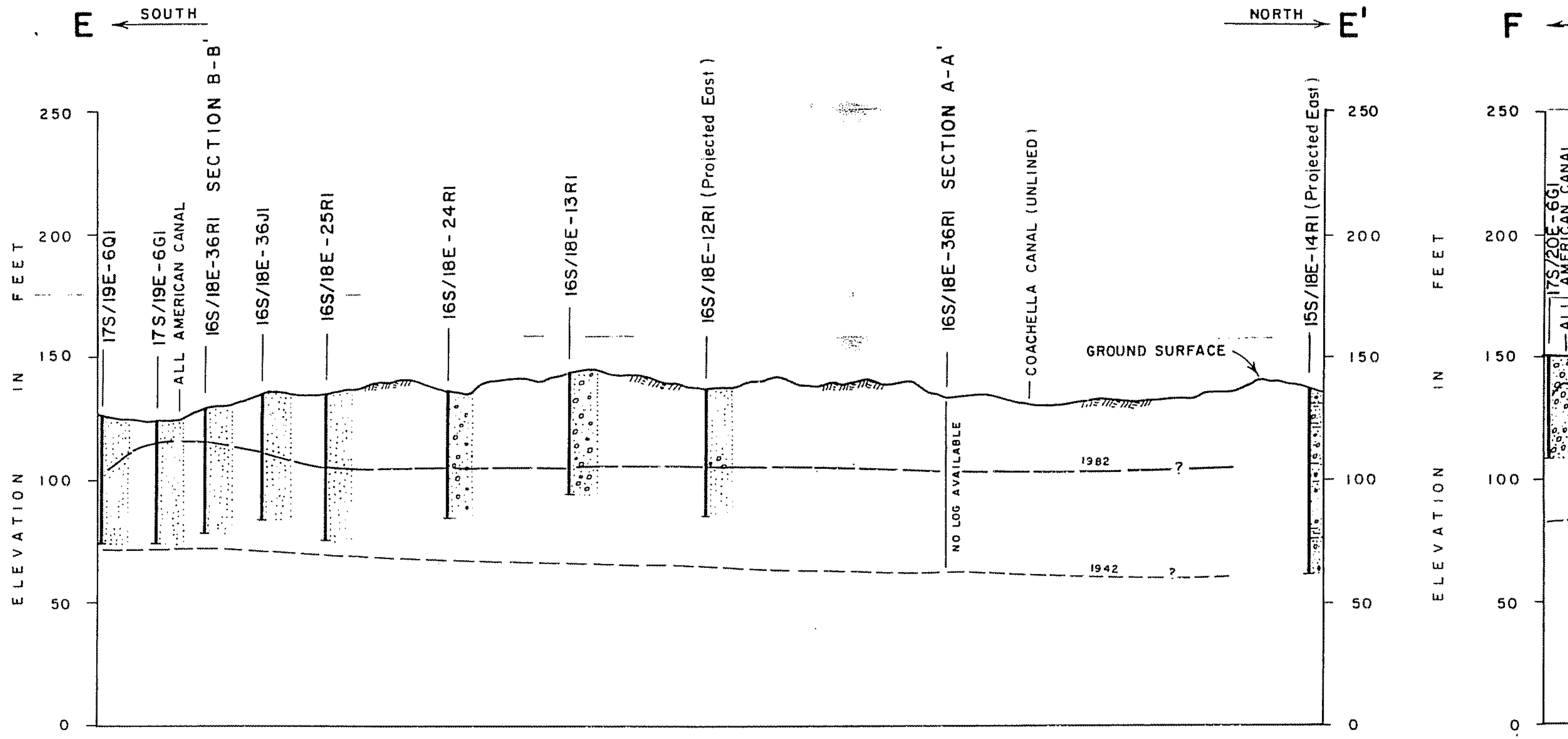


FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

CROSS SECTIONS C-C' AND D-D'

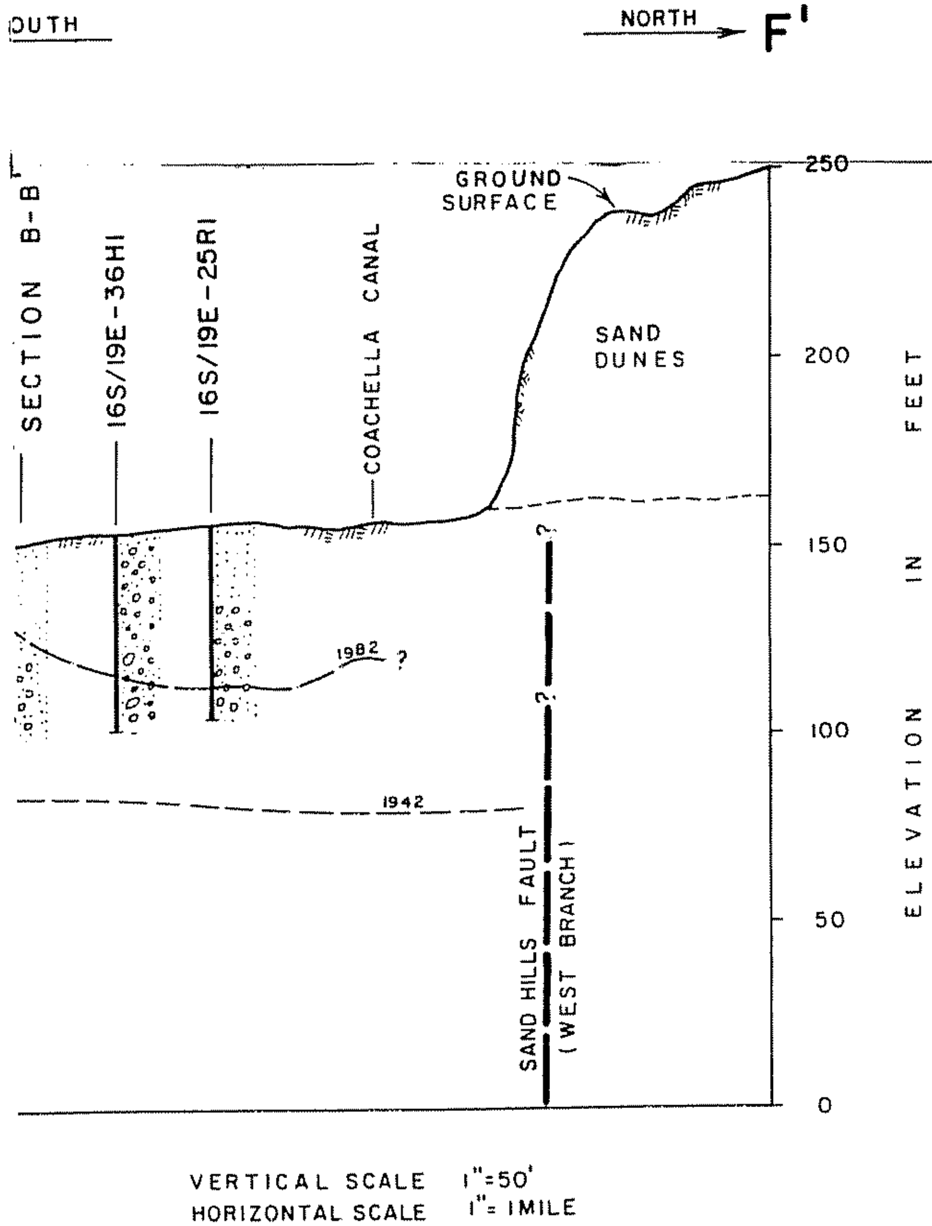
LeROY CRANDALL AND ASSOCIATES | PLATE 5

JOB E-83066 DATE 8-5-83 DR. M.G. O.E. CHKD.



VERTICAL SCALE 1" = 50'
HORIZONTAL SCALE 1" = 1 MILE

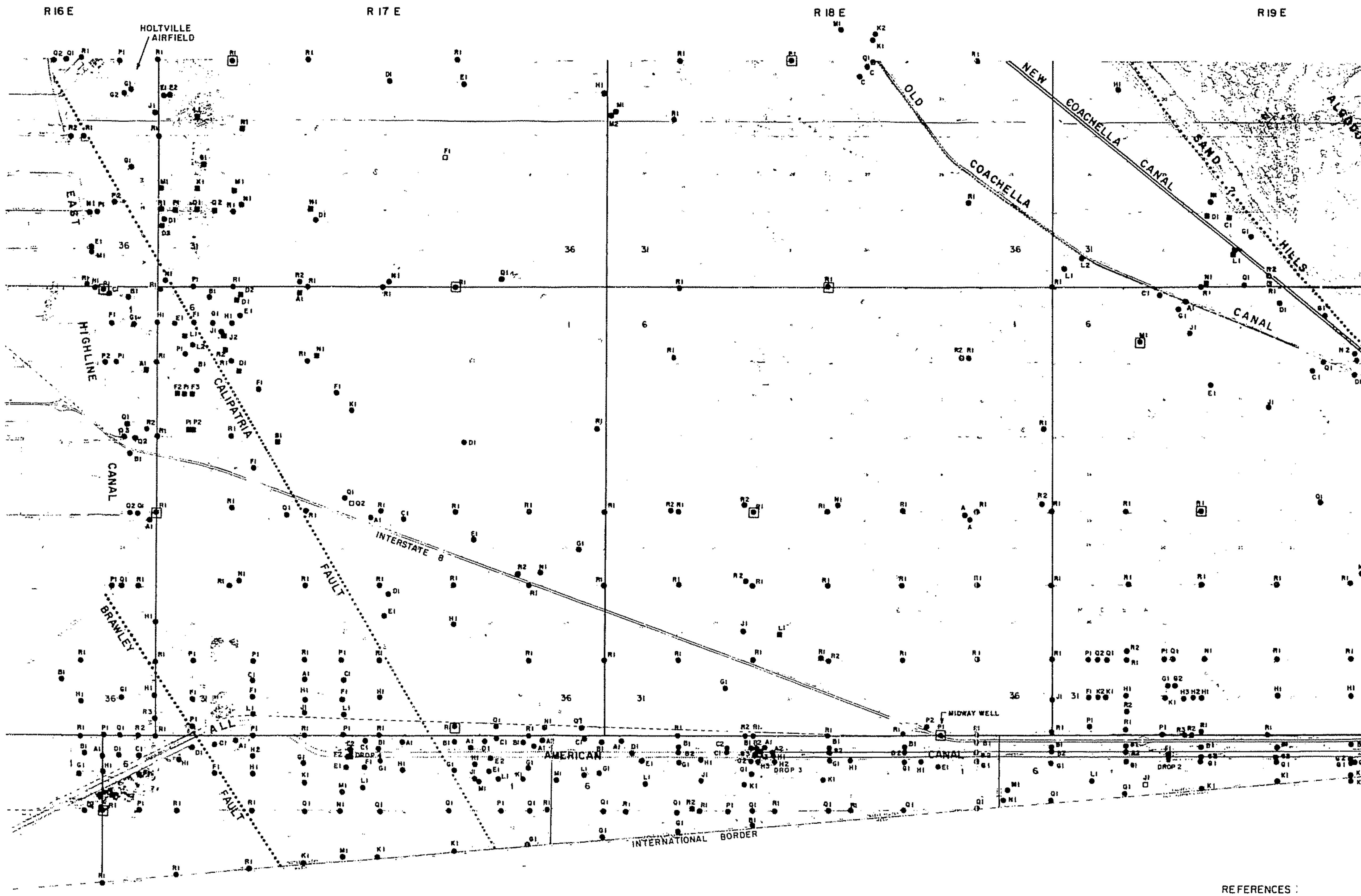
NOTE SEE PLATE 3 FOR EXPLANATION



FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

CROSS SECTIONS E-E' AND F-F'

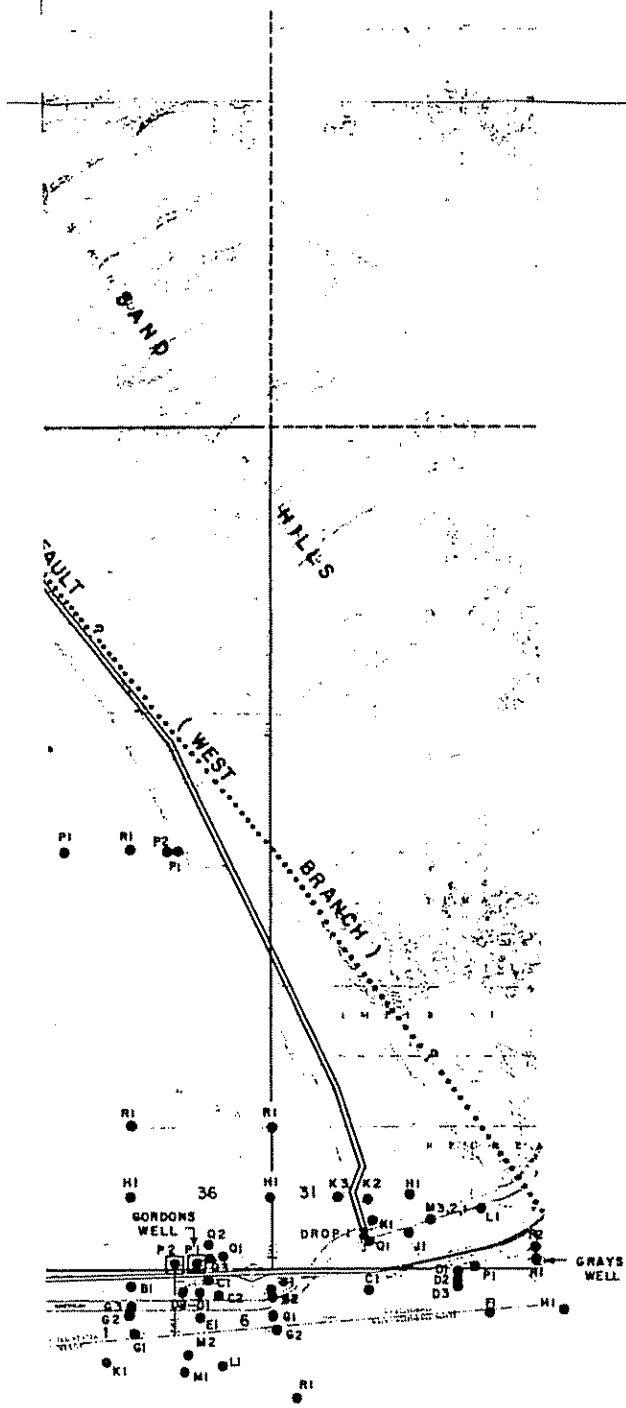
LeROY CRANDALL AND ASSOCIATES | PLATE 6



REFERENCES :
BASE MAP PREPARED
TOPOGRAPHIC QUADRANGL
CORNER, GLAMIS SW, M
MIDWAY WELL, CACTUS
FAULTS FROM MOI

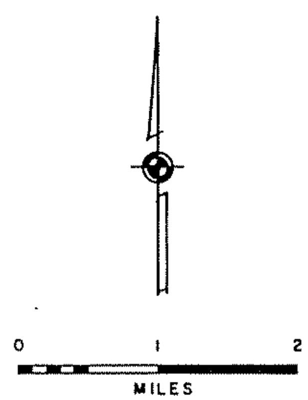
JOB E-83066 DATE 11-23-83 DR. M.G. O.E. CHKD.

R 20 E



EXPLANATION

- ● OBSERVATION WELL, WATER WELL, TEMPERATURE WELL OR TEST HOLE
- ▫ OIL OR GAS WELL OR DRILL HOLE
- ▪ GEOTHERMAL WELL OR DRILL HOLE
- K1 WELL, TEST HOLE OR DRILL HOLE NUMBER
- ...?... FAULT, APPROXIMATELY LOCATED OR CONCEALED
- ⊡ HYDROGRAPH OF WELLS ARE SHOWN ON PLATES 11 THROUGH 13



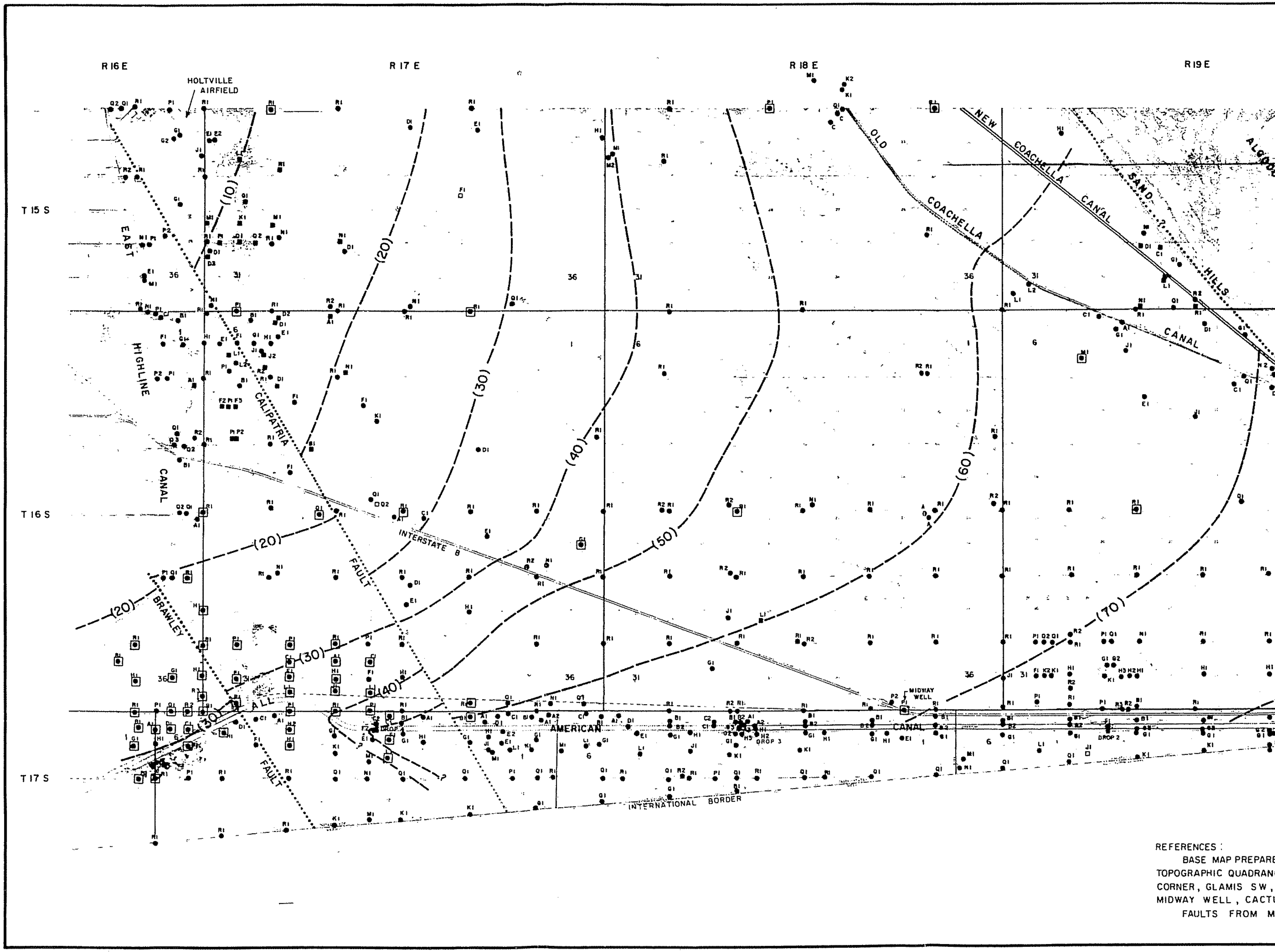
ROM U S G S 7½ MINUTE
; : HOLTVILLE EAST, BONDS
WAY WELL NW, GLAMIS SE,
AND GRAYS WELL
ON (1977)

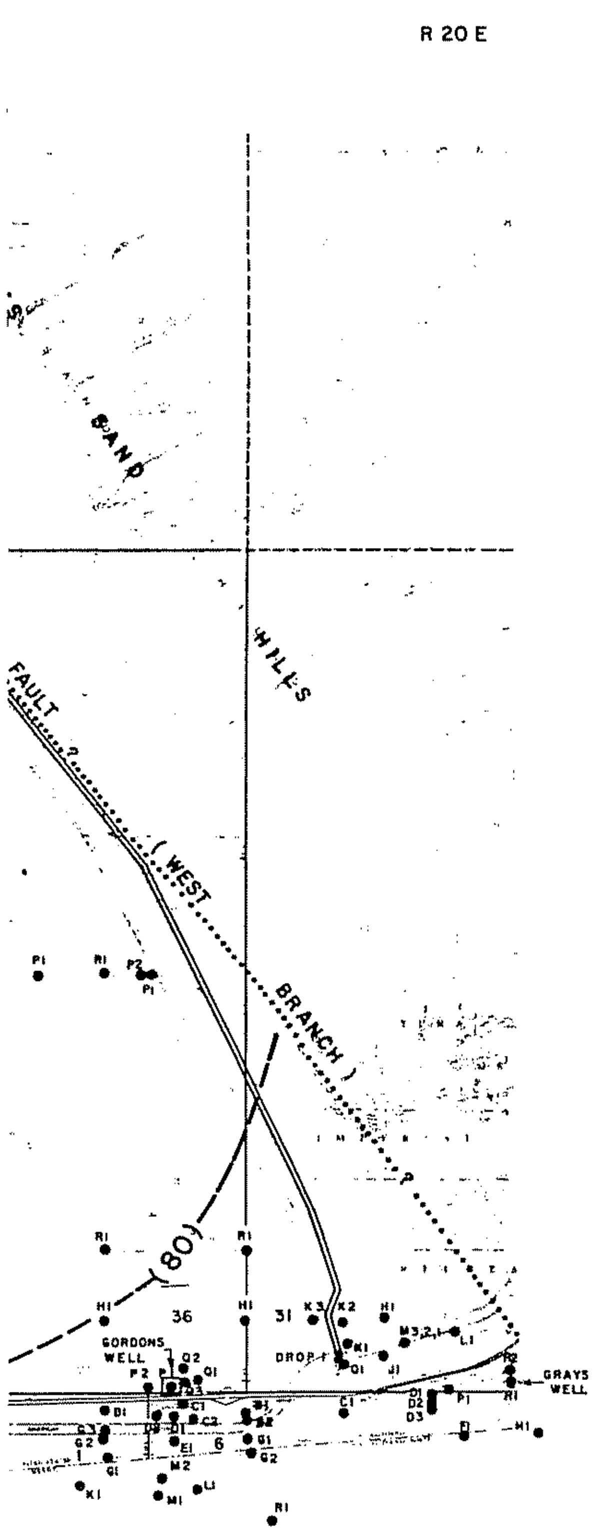
FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

WELL LOCATION MAP

LeROY CRANDALL AND ASSOCIATES	PLATE 7

JOB E-83066 DATE 11-23-83 DR. M.G. O.E. CHKD.





EXPLANATION

- OBSERVATION WELL, WATER WELL, TEMPERATURE WELL OR TEST HOLE
- OIL OR GAS WELL OR DRILL HOLE
- GEOTHERMAL WELL OR DRILL HOLE
- K1 — WELL, TEST HOLE OR DRILL HOLE NUMBER
- ....?... — FAULT, APPROXIMATELY LOCATED OR CONCEALED
- ——?— — LINES OF EQUAL GROUND WATER ELEVATION (IN FEET) QUERIED WHERE UNCERTAIN
- 1942 WATER LEVEL AVAILABLE FOR WELL

0 1 2
MILES

FROM U.S.G.S. 7½ MINUTE
.S : HOLTVILLE EAST, BONDS
OWAY WELL NW, GLAMIS SE,
AND GRAYS WELL
TON (1977)

FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

GROUND WATER CONTOUR MAP
OCTOBER, 1942

LeROY CRANDALL AND ASSOCIATES | PLATE 8

SIXTH ANNUAL PROGRESS REPORT

WATER QUALITY STANDARDS

FOR SALINITY

COLORADO RIVER SYSTEM

DECEMBER 1983

Prepared By The
Colorado River Basin Salinity Control Forum

COLORADO RIVER BASIN SALINITY CONTROL FORUM

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TABLE OF CONTENTS

TABLES

FIGURES

Sixth Annual Progress Report
Water Quality Standards for Salinity
Colorado River System

December 1983

Prepared by the
Colorado River Basin Salinity Control Forum

Introduction

In 1975, the seven-state Colorado River Basin Salinity Control Forum prepared a report which included numeric criteria and a plan of implementation and recommended that each state adopt the report as its salinity standards. Each of the Colorado River Basin states adopted the recommended standards which were approved by the Environmental Protection Agency (EPA) in November 1976.

The Clean Water Act requires that water quality standards be reviewed at least once each three-year period. Accordingly, in 1978, and again in 1981 the Forum reviewed the existing state-adopted and EPA approved salinity standards. Based on that review, the Forum found no reason to recommend changes in the numeric criteria.

The plan of implementation requires that the Forum's permanent Work Group analyze the progress and results of the salinity control program as well as other actions in the Basin which impact on the river's salinity. In addition, the states, through the Forum, have agreed to submit an annual report to the Environmental Protection Agency summarizing the results achieved by the salinity control program and the effect of other actions in the Basin having an influence on salinity. This report covers the period October 18, 1982 - September 30, 1983. 1/

Water Supply

The virgin flow at Lee Ferry, as estimated by the U.S. Bureau of Reclamation for the water years 1973 through 1982 is shown on Table 1.

TABLE 1
Virgin Flow at Lee Ferry
(1,000 Acre-feet)

Water Year	Flow
1973	19,395
1974	13,325
1975	16,921
1976	11,338
1977	5,470
1978	15,268
1979	17,793
1980	17,497
1981	8,236
1982	16,261

1/ The report period has been being changed to make it coincide with the water year.

The virgin flow for 1977 at Lee Ferry of 5.47 maf was the driest year on record for the period 1906-1982. The estimated virgin flow for water year 1983 is in excess of 24 million acre-feet which would make 1983 one of the wettest years on record.

Storage Changes

Upper and Lower Basin active reservoir storage has increased since 1972 as shown on Figure 1. Basinwide storage at the end of calendar year 1982 was about 16.3 million acre-feet greater than at the end of 1972. Of the total increase, 10.8 million acre-feet was in the Upper Basin and 5.5 million acre-feet was in the Lower Basin. The 1982 calendar year storage in the Colorado River system was about 5.1 million acre-feet greater than the 1981 value.

During water year 1983 all of the major reservoirs on the Colorado River filled to capacity and spilled. These large flows provided some immediate reduction in salinity concentrations at all of the major dams primarily due to dilution effects.

Historical Uses

Estimated historical Upper and Lower Basin uses for calendar years 1973 through 1982 are shown on Table 2.

END OF CALENDAR YEAR ACTIVE RESERVOIR STORAGE

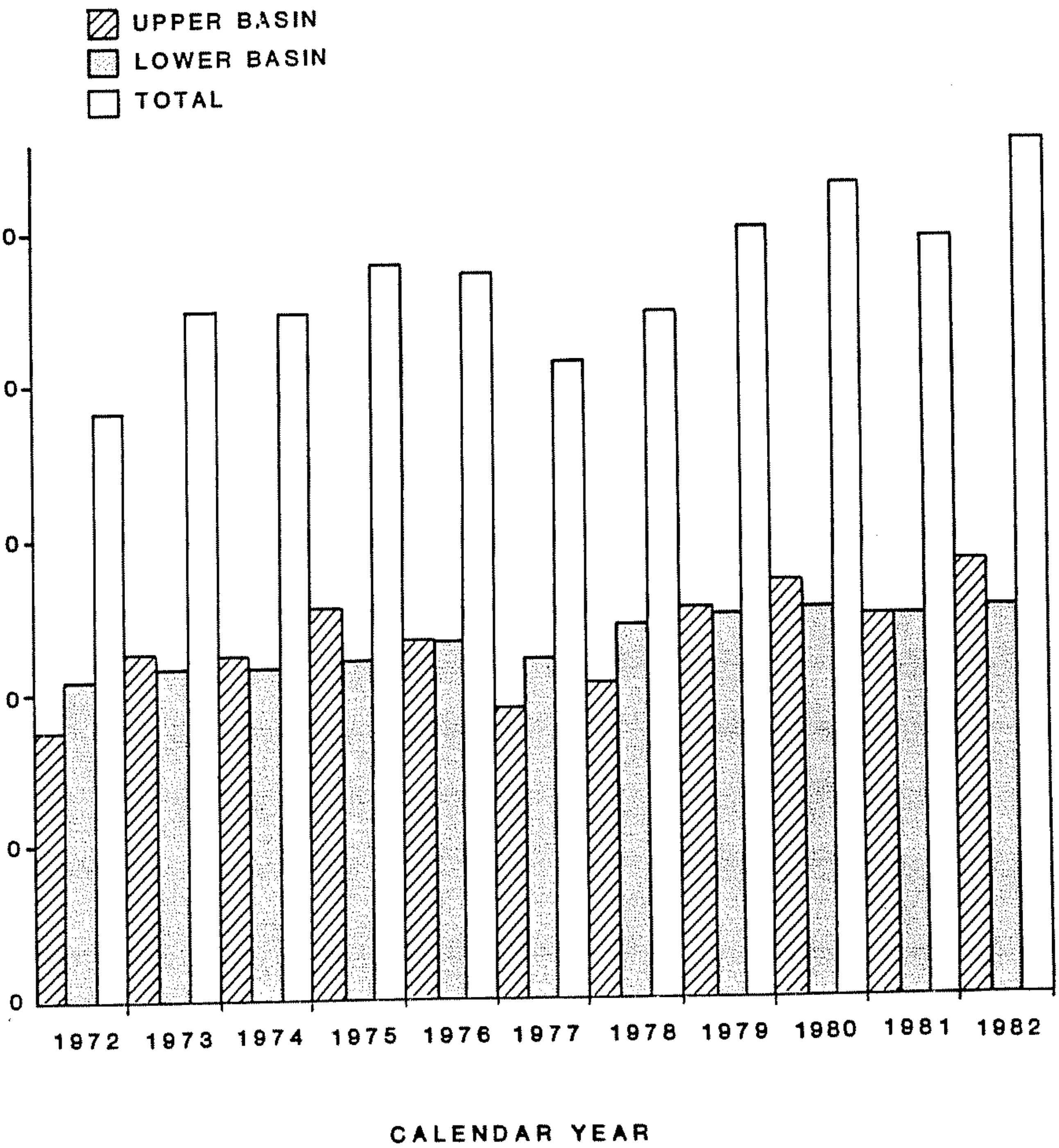


TABLE 2
SUMMARY OF ESTIMATED USES COLORADO RIVER BASIN
By Calendar Year
(Thousands of acre-feet per year)

By State	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Upper Colorado River Basin (Depletions)										
Arizona	7	21	34	26	33	30	35	36	34	34
Colorado** 8/	1,480	1,866	1,765	1,695	1,601	1,954	1,769	1,764	1,763*	1,791*
New Mexico	330 1/	208	305	279	221	315	394	403	301	397
Utah	705 4/	706	713	708	710	757	602 6/	900 7/	758	745
Wyoming**	320	330	334	337	355	358	379	382	372	450
CRSP Reservoir Evaporation	548	615	630	656	593	550	617	700	666	691
Subtotal - Depletions Upper Colorado River Basin	3,390	3,746	3,781	3,701	3,513	3,964	3,796	4,185	3,894	4,108
Lower Colorado River Basin (Mainstream Diversion less surface returns except as noted)										
Arizona 2/	962	990	1,011	1,094	1,038	1,076	950	975	1,090	1,044
California 2/	5,080	5,354	4,935	4,610	4,972	4,596	4,925	4,818	4,876	4,269
Nevada 3/	95	95	101	104	105	106	126	136	155	154
Subtotal - Mainstream Diversions less surface returns, Lower Colorado River Basin	6,137	6,439	6,047	5,808	6,115	5,778	6,001	5,929	6,121	5,467
Reservoir Evaporation	1,130	1,102	1,276	1,099	1,058	1,000	1,130	1,167	996*	1,300*
Deliveries to Mexico										
Scheduled	1,500	1,500	1,500	1,500	1,500	1,500	1,700	1,700	1,700	1,500
In Accord w/Minutes 241 and 242	119	160	216	206	207	182	178	155	148	150
Total to Mexico	1,619	1,660	1,716	1,706	1,707	1,682	1,878	1,855	1,848	1,650
TOTAL - Colorado River Basin 5/	12,276	12,947	12,820	12,314	12,393	12,424	12,805	13,136	12,859	12,525

1/ The 1973 depletions for New Mexico have been revised since publication of the Forum Report, "Water Quality Standards for Salinity Including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System." The values shown in the 1975 Forum Report have thus been superseded.

2/ Values of Arizona and California are diversions less returns including estimated unmeasured return flows.

3/ Values for Nevada are gross diversions.

4/ The estimated uses for Utah have been revised for the years 1973-1979.

5/ Includes all Lower Basin mainstem reservoirs and Senator Wash. Does not include net instream losses below Hoover Dam and tributary inflow between Lee Ferry and Hoover Dam estimated to average 200,000 af/yr and 750,000 af/yr, respectively.

6/ Starvation Reservoir drained. 7/ Starvation Reservoir refilled.

8/ The values for 1973 through 1980 have been revised.

* Provisional Record. ** Derived from U.S. Bureau of Reclamation data.

Salinity Concentration at Monitoring Stations

Salinity concentration at monitoring stations below Hoover Dam for years 1973 through 1982 are shown on Table 3. These values are all less than the 1972 numeric criteria.

TABLE 3
FLOW-WEIGHTED AVERAGE ANNUAL SALINITY CONCENTRATIONS
AT SELECTED STATIONS
(Total Dissolved Solids in mg/l*)

	Numeric Criteria	Calendar Year 1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Below Hoover Dam	723	706	686	685	674	667	686	694	706	678**	682**
Below Parker Dam	747	726	700	702	699	681	681	703	684	721**	717**
At Imperial Dam	879	846	836	828	823	821	812	809	758	816**	825**

*Determined annually by the Bureau of Reclamation from data collected by the U.S. Geological Survey.

**Provisional records.

Status of Salinity Control Activities

In this annual progress report, salinity control projects in which both Reclamation and Agriculture are involved are described as joint rather than separate projects. This should eliminate some confusion and better explain the status and progress in planning and implementing the various salinity projects.

Construction progress on the salinity projects authorized by Title II of P.L. 93-320 or other measures that would achieve equivalent reductions are necessary to maintain salinity in the lower mainstem of the Colorado River at or below the 1972 levels while the Basin states continue to develop their compact-apportioned waters is described in the paragraphs that follow.

Paradox Valley Unit

The brine inflow control program as proposed has been tested and verified. The brine disposal plan using deep well injection has been evaluated and is considered the most cost-effective and environmentally preferred disposal alternative.

Information obtained by the deep well drilling consultant resulted in a decision not to attempt rehabilitation of the abandoned Conoco Well in Paradox Valley. This change necessitated revising the deep well drilling specifications and delayed the contract award until January 1984. A later independent review of specifications for a new injection well showed that the specifications were inadequate for a well in the selected location of the salt dome. Therefore, additional study is needed to select another location for an injection well with a resultant delay in award of contract until about March 1985. The U.S. Geological Survey completed installation of all remote seismic stations, with testing to be completed in July, 1983.

The Bureau of Reclamation filed an application in February 1983 for a change of water rights and a plan for augmentation for the Paradox Valley Salinity Control Project.

This application would transfer water rights previously used on land in the McPhee Reservoir area of the Dolores Project to augment the depletions resulting from the operation of Paradox Valley well field. The water would provide replacement for the tributary saline water which would be pumped from the well field along the Dolores River to insure that downstream water users are not injured. The State of Colorado, acting through the Division of Water Resources and the Colorado Water Conservation Board, has filed "Statements of Opposition" in this water right proceeding. Under Colorado law, this is standard procedure to establish party standing in the case. The State of Colorado will work with the Bureau of Reclamation in an effort to resolve any issues which this filing may raise. No other entities have entered the proceedings.

Construction funding for the Paradox Valley Unit for FY 1983 is $3,620,000. The funding for fiscal year 1984 is $6,068,000.

Grand Valley Unit

Both USDA and Reclamation are involved in the Grand Valley Unit. Reclamation activities are divided into Stage One and Stage Two project areas. USDA onfarm water management and salinity control efforts are underway project-wide.

Reclamation - The lining of 6.8 miles of the Government Highline Canal Stage One is complete. The associated laterals were completed prior to the 1983 irrigation season.

Monitoring continues on the Stage One laterals for flow fluctuations or operational problems. The moss and debris removal structure was installed in 1983, approximately 1 year ahead of schedule. Monitoring of the Stage One area has shown a reduction in salt load of 15,600 tons of which 14,200 tons was related to the canal and lateral lining and 1,300 tons to the USDA onfarm program in the Stage One area.

A recommended plan has been identified in the Stage Two draft supplement to the Definite Plan Report. This plan would reduce salinity concentration at Imperial Dam by 14.1 mg/l and result in an overall cost-effectiveness of $618,000 per mg/l. The selected plan includes concrete lining the west, middle, and east reaches of the Government Highline Canal and all laterals in the Stage Two area except the Redlands. Lining of the middle and east sections of the Government Highline Canal will be deferred until needed to meet goals of the salinity control program.

Reclamation has completed a reevaluation of the salt load contribution from the Grand Valley area. Although the studies show an estimated salt load reduction of 200,000 ton/year (780,000 tons vs 580,000 tons) the change in loading did not affect the potential salt reduction by the combined Reclamation and USDA program of 410,000 tons per year.

Fiscal year 1983 funding for construction in Grand Valley amounted to $8,860,000. The FY 1984 budget amount is $3,915,000.

USDA onfarm - USDA onfarm activities are underway throughout the project area. The Soil Conservation Service completed an onfarm salinity control report in December 1977 and provided a supplement in March 1980 to cover the onfarm-related lateral improvement program. Implementation of the USDA onfarm and related lateral improvement program was initiated in 1979.

For 1982, SCS personnel estimate the Grand Valley average annual salt load reduction by the USDA onfarm program for the entire valley, including the Stage One area, to be 17,700 tons, with an average annual salinity concentration reduction of 1.84 mg/l at Imperial Dam. SCS has initiated a more comprehensive onfarm monitoring and evaluation program in Grand Valley. Specialized monitoring equipment has been purchased and installed to measure climatic conditions (precipitation, wind direction and velocity, etc.) for use in determining evapotranspiration rates and for measuring field irrigation inflows and outflows. This data will be used to determine irrigation efficiencies and amounts of deep percolation. The monitoring program was initiated on several farms and will be further expanded to approximately 30 farms per year as funding levels increase in future years.

An agricultural extension agent has been hired in Grand Valley through a cooperative agreement between Reclamation and USDA Extension Service in conjunction with the Colorado Cooperative Extension Service. The agent is working full time to contact local landowners regarding the organization of small group laterals as part of the Reclamation and USDA lateral improvement program in Grand Valley. The organization of lateral operators into more formal entities is necessary to strengthen coordination and implementation of the Reclamation lateral program and the USDA onfarm program.

Las Vegas Wash Unit

The status report, dated October 1982 was released in December 1982. The report presented recent study findings and recommended modifications to the salinity control plan for Las Vegas Wash. The major finding of the study was that the salt loading was induced by the disposal of waste water into wasteways or basins which leach salt from the underlying saline geologic deposits. A recommended solution is to channel the waste water around the saline deposits which would reduce the leaching and salt loading.

The salt pickup could be reduced by 79,000 tons per year by a 4.5-mile bypass channel which would convey, with minimal seepage, waste water and minor storm runoff along the north side of the Wash flood plain.

Reclamation has begun a verification program in the Pittman area which would monitor the ground water response to the elimination of waste water seepage from unlined ditches. A 3.5-mile Pittman bypass pipeline was delayed until fiscal year 1984.

An effort is being made to coordinate the proposed salinity control action with plans of Clark County agencies.

Opposition has been expressed against the proposed bypass channel by several local entities. Although there are several issues of contention, the primary concerns appear to be two fold. The first concern relates to the possible impacts the bypass channel would have on the existing and proposed wetlands environment in the Las Vegas Wash. The second concern relates to the possible reduction of the nutrient stripping capability of the wetlands if the waste water effluent is bypassed around the Las Vegas Wash, thereby increasing waste water treatment costs. Other concerns which have been expressed relate to the cost and benefits of the salinity control project. The Bureau of Reclamation has been and continues to work closely with the local entities in addressing these issues.

A Finding of No Significant Impact (FONSI) for the Pittman Verification Program and Environmental Assessment Report was signed in May 1983. This report outlines the concept of a vegetation test plot which would determine and demonstrate the feasibility of establishing and maintaining native vegetation with available ground water. This concept was developed in consultation with the Fish and Wildlife Service. The test site is a means of obtaining data necessary for successful implementation of the salinity control project, demonstrating the compatibility of salinity control plans and wetland park plans, and securing public support of a salinity control project.

The appropriation for FY 1983 was $857,000. For FY 1984 $1,075,000 has been appropriated primarily for completion of the Definite Plan Report (DPR) and Pittman bypass.

Water Quality Improvement Program

Since the publication of the Fifth Annual Progress Report and the 1981 Review - Water Quality Standards for Salinity, some changes have been made in the scheduled completion dates for feasibility reports on the units identified in Public Law 93-320 and Public Law 96-375. Table 4 presents a summary of the various planning reports and includes an explanation of the status of related USDA onfarm program reports. In some projects, USDA is not involved.

The Forum continues to urge Reclamation and Agriculture to coordinate their planning activities and schedules to run concurrently to the greatest extent possible.

TABLE 4
Water Quality Improvement Program
Estimated Completion Planning Reports

Unit	1981 Standards Review March 6, 1979 Schedule	Revisions[1] Sept. 1982	USDA Reports
AQUATRAIN	-	9/85	-
Big Sandy River	5/84	5/84	Publ. 11/80
Colo. River Indian Reserv.	-	-	10/84
Dirty Devil River	2/87	1/87	-

1/ Proposed revisions, subject to change

Glenwood-Dotsero Springs	5/84	6/86	-
LaVerkin Springs	-	86	-
Little Colorado	-	-	Publ. 12/81
Lower Gunnison	12/81	12/82	Publ. 9/81
Lower Virgin River	-	87	Publ. 3/82
Mancos Valley	-	-	5/84
McElmo Creek	9/83	2/84	Publ. 1/83
Meeker Dome	2/83	6/85	-
Moapa Valley	-	-	Publ. 2/81
Price-San Rafael Rivers	3/86	9/85	10/84
Palo Verde I.D.	-	-	Not scheduled
Uinta Basin	3/83	4/84	Publ. 1/79

Big Sandy River Unit - The current plan, recommended by Reclamation, would remove saline water by collection wells in the spring and seep area of the Big Sandy River and pump the water via a pipeline to a proposed Chevron fertilizer plant near Rock Springs for use and disposal. The final Reclamation/State joint report was presented to the State Legislature in December 1982. The State has provided funds for acceleration of the study through the Wyoming Water Development Commission. Draft appendices and the draft plan formulation working document have been completed and are under review. The recommended plan was reformulated to exclude the Bone Draw Collector well field. The State of Wyoming may consider an independent review by an engineering consultant of the USDA and Reclamation plans.

Implementation of USDA's onfarm program has been delayed pending resolution of the Reclamation off-farm salinity studies.

Lower Gunnison Basin Unit - Reclamation's planning report and draft Environmental Statement were filed on January 4, 1983. A final Environmental Impact Statement and Planning Report is currently scheduled for early 1984. Basic data collection on Stage II is underway.

Preconstruction planning was scheduled to begin in FY 1983 on the winter water portion of Reclamation's plan but was cut from the program because of budgetary restrictions. This activity is rescheduled to begin in FY 1984.

The USDA Soil Conservation Service onfarm report is compatible with and focuses upon the same priority salt load problem areas on the east side of the Uncompahgre River, as does Reclamation's plan. Implementation of the onfarm program is scheduled to begin in fiscal year 1986.

Uinta Basin Unit - Coordination between Reclamation and USDA has been maintained in the progress of this unit study. USDA continues to proceed with their onfarm implementation program and is working on a number of canal and lateral improvements. The majority of the canal and lateral improvements needed in the basin are being accomplished through the Central Utah Project. About 59 miles of canals and laterals are proposed for rehabilitation under Reclamation's study. Initial data collection for preconstruction planning was scheduled to begin in fiscal year 1983 but was cut from the program because of budgetary restrictions.

USDA has also initiated a more comprehensive onfarm monitoring and evaluation program in the Uinta Basin. For 1982, SCS personnel estimate the average annual salt load reduction to be 12,800 tons as a result of their efforts, with a resulting 1.3 mg/l decrease in salinity concentration at Imperial Dam.

McElmo Creek Unit - The Forum found through a special consultant's study that the proposed Reclamation report and the completed USDA onfarm report complement each other rather well. While the water and salt budgets prepared by the two agencies vary, the estimated values for total salt load and for potential salt load reduction are within acceptable limits. The Forum has recommended that the USDA program be accelerated.

The Reclamation study plan formulation working document was completed. The Planning Report/Draft Environmental Statement is scheduled for February 1984. The recommended plan was to line 28.5 miles of the Montezuma Valley Irrigation Company (MVIC) system. The possibility of combining the Towaoc Canal with canals in the MVIC distribution system has been discussed. A decision was made to construct much of the McElmo Creek Unit's recommended plan under the Dolores Project and to combine the Towaoc-MVIC canals as part of the plan. Analyses indicate that there is not only a cost savings in rerouting the Towaoc Canal from the west side to the east side of the City of Cortez, but substantial savings accrue if the Towaoc Canal is combined with canals of the salinity control unit.

Palo Verde Irrigation District Unit - Reclamation and USDA have worked together to formulate a joint plan of study which will be conducted in three phases. Additional discussions on the proposed plan of study with local entities are planned for late 1983. Reclamation and USDA funding may delay the start of the study until 1985.

Meeker Dome Unit - Monitoring is continuing. Well cleaning and plugging still appears successful.

A salt concentration reduction is expected to average 1.6 mg/l at Imperial Dam as a result the plugging of the three wells in 1981. . The planning report to document the verification program is scheduled to be completed by June 1985.

LaVerkin Springs Unit - Because of renewed State and local interest, Reclamation reinitiated salinity studies in FY 1983 to evaluate a new concept for diverting the saline springs to clay-lined evaporation ponds. Clay lining was not seriously considered in previous studies by Reclamation because of concerns for ground water intrusion. Washington County Water Conservancy District, a local entity, has suggested that clay lining would be acceptable for saline water disposal.

Detailed studies are continuing to specifically address downstream Virgin River effects on salt removal estimates and to revise the costs of evaporation ponds for selected liner materials.

The District is interested in reducing salinity and providing water from the Quail Creek Project to replace depletions caused by the evaporation of saline water.

Lower Virgin River Unit - USDA has published a Virgin Valley onfarm salinity report. Implementation of the USDA program hopefully will be initiated in 1984.

Further Reclamation studies have been programmed to begin in FY 1984 to investigate the viability of capturing Lower Virgin River saline underflows and surface flows and diverting them for industrial use as powerplant cooling water. Both the State and the Nevada Power Company have expressed interest in the project. Previous Reclamation studies were conducted further upstream.

Glenwood-Dotsero Springs Unit - Reclamation's preferred plan for study is expected to decrease the salt loading to the Colorado River by an average of 284,000 tons annually. Brine would be collected from Glenwood and Dotsero Springs and delivered via a 140-mile pipeline to evaporation ponds for disposal near West Salt Creek on the Colorado-Utah border. Another disposal alternative is to utilize the saline water for AQUATRAIN.

Price-San Rafael Rivers Unit - Reclamation and USDA continue to coordinate planning efforts. Preliminary findings indicate canal lining may not be cost-effective, while a livestock winter watering pipeline would be cost-effective. USDA planning efforts are focusing on onfarm systems improvements, some replacement canal and/or lateral structures and a heavy emphasis on providing onfarm water management assistance. The USDA onfarm report is scheduled for completion in October 1984 while Reclamation's report is scheduled for completion in FY 1985.

Saline Water Use and Disposal Opportunities (Saline Water Cooling Tower Verification Program) - Reclamation is working with the Forum, EPA, utilities, and others to identify a proper site and cost-sharing possibilities for installation of a saline water cooling tower at a power plant located in the Colorado River Basin. Installation of a binary cooling tower at an existing power plant appears to be the most cost-effective way to verify the use of saline water to provide salinity control benefits and address industries' concerns regarding equipment reliability. Cost-sharing agreements, equipment design, and an operational plan for installation and operation of the verification unit are expected to be completed in FY 1984, with installation of the verification facilities scheduled for initiation in FY 1985.

Saline Water Use and Disposal Opportunities (AQUATRAIN) In November 1982 an agreement was signed between Reclamation and W.R. Grace & Co. An agreement was signed in March 1983 with Bureau of Land Management to do corridor screening and environmental studies. Private interests and other Federal agencies are providing personnel for this study which is expected to be completed in FY 1985.

Technical analysis during the past year indicates that liquid carbon dioxide will provide a significantly greater economic transport medium than saline water. As a result, Aquatrain is now being formulated to use saline water as conjunctive cooling water for power plants.

<u>Funding</u> - During the fiscal year 1983, the Reclamation level of funnding for the Water Quality Improvement Program was $5,604,000. Funding for FY 1984 is for $4,510,000 for planning activities on the above units. An additional $540,000 has been requested for advance planning activities.

<u>Research</u> - Reclamation's research activities and contracts on reservoir salt precipitation and evaporation and analysis of water chemistry data to isolate changes in basin salt loading are moving forward. Research activities are continuing on softening pretreatment and water characterization studies and work on saline water cooling tower technology as a part of the Saline Water Use and Disposal Opportunities Unit.

U.S. Department of Agriculture (USDA) Other Activities

The USDA continues to be a valuable and active participant in the Colorado River Basin Salinity Control Program. The Soil Conservation Service (SCS) has provided excellent leadership in helping plan and implement the more cost-effective onfarm salinity control activities necessary to achieve the objectives identified in Title II of PL 93-320.

Planning - Because of FY 1983 funding limitations, USDA salinity control project planning activities were extremely limited. USDA was able to complete a draft report on the very small Mancos Valley project and has coordinated with Reclamation to formulate a proposed report on the Price-San Rafael irrigated areas. Other than some minor revisions to the McElmo Creek Report, no new salinity control reports were completed in the last year. It has been determined that the Colorado River Indian Reservation is not a major salt contributor, and a standard USDA river basin study is being conducted on this area.

Salinity studies have been completed on 508,000 acres in eight different areas that have a maximum salt load reduction potential of nearly 850,000 tons per year when fully implemented. The Upper Virgin and Palo Verde salinity studies have been delayed because of funding difficulties.

Implementation - USDA continues to implement the Grand Valley and Uinta Basin onfarm salinity control projects through existing USDA programs. Technical assistance for onfarm planning, design and installation, and followup water management support is provided by SCS through the Conservation Technical Assistance funds. Cost-share support for water management and salinity control practices are funded through the Agricultural Conservation Program administered by the Agricultural Stablization and Conservation Service. While existing programs provide an opportunity for some implementation to occur, the Forum continues to urge the Department, the Administration, and Congress to establish necessary legislative authority for a separate Colorado River Salinity Control Program to be funded under the Secretary of Agriculture.

Research and Education - In FY 1983, the Agricultural Research Service (ARS) received an additional $600,000 funding to expand upon salinity related research. Through the efforts of various ARS salinity and water conservation research facilities, an expanded salinity research effort has been initiated. This research effort while targeted for Colorado River salinity control, will provide research information and improved technology which will benefit other national salinity activities. Ongoing activities on new and developing irrigation techniques such as cablegation and level-basin irrigation systems in Grand Valley have proven quite successful. The successful use of saline or brackish drainage return flow water in controlled field experiments in the San Joaquin and Imperial Valleys will also be useful in the Colorado River Basin.

The Cooperative State Research Service (CSRS) and the State agricultural experiment stations in the West have a regional research project through which cooperative research is planned and carried out. The project known as "The Physico-Chemical Basis for Managing Salt-Affected Soils" and is aimed at understanding physical and chemical factors that affect the reclamation of soil and geologic materials, and determining and quantifying chemical and mineralogical properties of carbonates and evaporites in salty soils, geological formations and water. In FY 1982 the participating state experiment stations spent over $294,000 on the project of which $57,000 were federal funds and $236,500 were state funds.

Monitoring and Evaluation - Field monitoring activities through Colorado State University and ARS indicated that additional research and field data are needed to further improve furrow irrigation system design procedures and criteria. Many variables such as soils, crops, type of systems, and quality of water management influence the design and effectiveness of irrigation systems. Additional monitoring and evaluation data is needed to further define the impacts on reducing deep percolation and ultimate salt load reduction. With additional data, the cost-effectiveness of various practices can be better assessed. A major conclusion is that more extensive funding and staffing are needed to provide support for the very important onfarm water management and scheduling needs.

USDA has initiated a more comprehensive onfarm monitoring and evaluation program in both the Uinta Basin and Grand Valley. Specialized monitoring equipment has been purchased and installed to measure climatic conditions (precipitation, wind direction and velocity, etc.) for use in determining evapotranspiration rates and for measuring field irrigation inflows and outflows. These data will be used to determine irrigation efficiencies and amounts of deep percolation. The monitoring program has been initiated on several farms and will be expanded to approximately 30 farms per year for each project as funding levels increase in future years. An effective onfarm monitoring program is necessary to measure the salinity impacts of the USDA program.

Budgeting - USDA and the Administration submitted a FY 1984 budget request for $12.5 million for planning, implementation, and monitoring. The request increases funding for Colorado River salinity control and proposes the creation of a singular consolidated account for the program. At this point, the Congressional Agriculture Subcommittees have not supported the Administration's proposal. Without new authorities and separate funding, the program can only be supported through existing programs.

Bureau of Land Management

In FY 1983 the Bureau of Land Management's salinity control efforts were concentrated on the Sinbad Valley Project, and the identification of highly erosive saline areas where watershed rehabilitation measures could be implemented.

The Sinbad Valley Salinity Report was completed in April 1983. The report identifies two alternatives with very similar cost effectiveness. The total cost of each of the two alternatives is approximately 7.5 million dollars, with a cost per milligram per liter at Imperial Dam for each of the two alternatives of approximately $750,000. The Assistant Secretary of the Interior for Land and Water Resources has decided that if the Sinbad Valley Unit is to be implemented, it will be done by the BLM.

Presently, the BLM is operating a streamflow and water quality monitoring station, along with a recording rain gauge in the Salt Creek drainage. Any additional future work on this project will require special Congressional funding.

Watershed rehabilitation, through watershed control measures, according to BLM, provides an appropriate approach to salinity control from a land management standpoint because of the multiple use benefits. These multiple use benefits include salinity and sediment reductions, increased forage production, greater distribution of livestock by an increase in water sources, increased wildlife habitat, and flood control. Reports identifying potential salinity control areas have been completed for Eastern Utah, and the Montrose, Craig, and Grand Junction areas in Colorado. A Draft Watershed Management Plan, which includes salinity control, has been completed for the Red Creek Drainage in Wyoming.

To be considered for implementation of watershed control measures, an area must have the following three characteristics:

1. The project area is a major contributor of salt and sediment due to surface runoff and erosion.

2. Surface runofff and erosion rates are high, in part, because of past management practices, and can be reduced by

proper watershed management.

3. Watershed management activities will complement watershed planning.

Watershed treatments have been implemented in a small portion of the Leach Creek drainage near Grand Junction, Colorado, in FY 1983. Leach Creek is one area identified for salinity control in the Grand Junction area Report. Approximately 100 acres of the watershed will be treated through construction of a series of small check dams and retention reservoirs. The treatment area consists of steep badlands with erosion rates of approximately 9 tons/acre, with a salt content of approximately 3 percent. When implemented 880 tons of sediment and 22.5 tons of salt per year should be controlled. Similar areas within Leach Creek are scheduled for treatment in the future.

In addition to the above, the BLM is sponsoring a project entitled "Modeling of Surface Mining on DissolvedSolids in the Yampa River" and is being conducted by the U.S. Geological Survey. The objectives of this project are to identify and calibrate the relationship of existing dissolved solids with discharge for the tributary system of the Yampa River above Maybell, Colorado; and to assess through model simulation, the potential increases in dissolved solids of streams as a result of increasing levels of mining. This project is scheduled for completion in FY 1984.

Fish and Wildlife Service (FWS)

This is the first time the Forum has included a discussion of the Fish and Wildlife Services' (FWS) activities related to salinity control. Therefore, the discussion has been expanded to give some background.

Fish and Wildlife Service responsibilities including those set forth in the Endangered Species Act, Fish and Wildlife Coordination Act, Clean Water Act, National Environmental Policy Act, and the Migratory Bird Treaty Act provide for FWS participation in the Colorado River Salinity Control Program. It is mainly through these legislative authorities that the FWS works toward meeting its objective to provide the federal leadership to conserve, protect, and enhance fish and wildlife and their habitat for the continuing benefit of people.

FWS currently is involved with 13 of the salinity control units under study in the Colorado River Basin. The complexity and ecological isolation of the Colorado River Basin is reflected in its biological diversity of fish and wildlife resources and great number of unique species. This river system has the largest list of threatened and endangered fish and wildlife species in the United States as well as significant other resources including migratory birds and waterfowl, non-migratory birds, big game, wetlands, riparian lands, and other habitats that support wildlife. Of the 13 salinity control units, 10 are located within FWS's Region 6 boundary whose participating offices include Salt Lake City, Utah; Grand Junction and Denver, Colorado Region 1 participating offices in Reno, Nevada; and Laguna Niguel, California have jurisdiction over the other three units (Table 5). The Denver Regional Office has been assigned responsibility for overall coordination within the FWS. FWS participation in 1983 amounted to about 33 staff months of effort exclusive of consultation activities as required by Section 7 of the Endangered Species Act.

Table 5 - FWS Involvement in Salinity Control Studies - 1983

Project	Region	Office	Status Fish and Wildlife Coordination Act Report
Paradox Valley	6	Grand Junction, CO	1986
Grand Valley	6	Grand Junction, CO	1984
Glenwood Dotsero	6	Grand Junction, CO	1984
McElmo Creek	6	Grand Junction, CO	Completed
Lower Gunnison	6	Grand Junction, CO	Completed
Big Sandy	6	Salt Lake City, UT	Unscheduled (Draft Planning Aid Memo, July 1983) Report
Price-San Rafael	6	Salt Lake City, UT	Unscheduled
Uinta Basin	6	Salt Lake City, UT	May 1983 (Draft
Dirty Devil	6	Salt Lake City, UT	Unscheduled (Draft Planning Aid Memo, May 1983)
La Verkin Springs	6	Salt Lake City, UT	1984
Lower Virgin River	1	Reno, NV	Planning Aid Memo Prepared
Las Vegas Wash Pittman Bypass	1	Reno, NV	Final Out on Pipeline Portion of Project
Coachella Canal	1	Laguna Niguel, CA	---

General FWS activities during 1983 consisted of evaluating salinity control unit proposals and preparing related Fish and Wildlife Coordination Act reports, Planning Aid Memorandums (See Table 5 for status), biological opinions, and commenting on draft Environmental Impact Statements and biological assessments.

FWS input to planning salinity control units also is provided through participation in a variety of working/planning meetings with the Bureau of Reclamation, Soil Conservation Service, Bureau of Land Management, State water development agencies, fish and wildlife resource agencies, Indian tribes, and the public. As required by the Endangered Species Act, lists of threatened or endangered species in salinity control project areas, and biological opinions are provided by the FWS. Draft biological opinions for the Big Sandy Unit and the Glenwood-Dotsero Springs Unit are due to be completed in October 1983. Based on the biological assessment prepared by the Bureau of Reclamation for the Grand Valley Unit, the FWS determined that the project would have "no effect" on the threatened and endangered species occuring or thought to be occuring in the project area. Non-jeopardy biological opinions, meaning formal consultation has been completed with the conclusion that the project "is not likely to jeopardize the continued existence of the threatened or endangered species", have been previously given for the following units: Paradox Valley, McElmo Creek, Lower Gunnison River, and the Uinta Basin.

Environmental Protection Agency

The major Environmental Protection Agency (EPA) programs dealing with salinity control (Water Quality Management Planning and NPDES permits) are largely delegated to the States. Therefore, these programs are discussed in other sections of this report. EPA maintains oversight responsibilities for these delegated programs. For example, EPA has reviewed and commented on NPDES permit applications for the Jim Bridger Power Plant, Clark County Sanitation District, and the San Juan Power Station. Congress has approved funding for Section 205(j) of the Clean Water Act, and this money may be available for State and areawide salinity control programs.

In testimony before the Senate Subcommittee on Water and Power on the proposed amendments (S. 752) to the Colorado River Basin Salinity Control Act, EPA submitted a statement in support of the cooperative, basinwide salinity control effort. EPA continues to encourage the Basin States to develop and implement the state salinity control strategies.

The Forum and EPA policy encouraging the use of poorer quality water for industrial purposes is being supported primarily through NEPA (Environmental Impact Statements, EIS) review responsibilities. Also, through the NEPA review process, EPA urges the identification of potential salinity impacts resulting from proposed projects as well as discussion of mitigation of adverse impacts as required by the Council on Environmental Quality regulations (40 CFR Parts 1500-1508) for implementing the National Environmental Policy Act. For example EPA has commented on potential salinity impacts in reviewing grazing and land management EIS', oil development EIS' and water development project EIS'.

EPA continues to work with Reclamation on the underground injection control requirements for the Paradox Valley salinity control unit.

State Salinity Control Activities

National Pollution Discharge Elimination System (NPDES) Permits

All states have adopted the 1977 Forum Policy for Implementation of the Colorado River Basin Salinity Standards Through the NPDES Permit Program. A copy of the policy can be found in the 1978 Revision of the Water Quality Standards for Salinity. During the period of this report, the status of implementation was as follows:

Arizona - Authority for issuing NPDES permits has not been delegated to the state. Permits are prepared by the state, then approved and issued by EPA, Region IX.

In the Colorado River Basin in Arizona above Imperial Dam, seven permits for waste water discharges were issued during the period October 1, 1982 through September 30, 1983. These included three municipal permits and four permits for industrial discharges, principally for excess storm drainage water from containment facilities at mines. One permit for a municipal waste water discharge was denied. The permits require that both source water and discharge TDS be monitored for compliance with the Forum's policy.

The Department of Health Services recently reviewed monitoring reports of facilities potentially discharging under NPDES permits. No system was discharging more than one ton per day or 350 tons per year of TDS and in most cases discharges are remote from the mainstream of the Colorado River.

California - The California Regional Water Quality Control Board, Colorado River Basin Region, issues the NPDES permits and waste discharge requirements within the Colorado River drainage portion of the state. The City of Needles is scheduled for reissuance of its municipal discharge permit. The Regional Water Quality Control Board's proposed requirements are consistent with the adopted Forum policy.

In implementing the objectives of the Water Quality Control Plan for the East Colorado River Basin, the California Regional Water Quality Control Board has included in most discharge permit requirements a prohibition of brine backwash from water softeners to the Colorado River and into ground waters which are in hydraulic continuity with the Colorado River System.

Colorado - Authority for issuing discharge permits in Colorado has been delegated to the Colorado Department of

Health. There are 138 permits, 63 of which are industrial, in the Colorado River Basin portion of the state. All new permits and reissued discharge permits in the basin are being brought into compliance with the Water Quality Control Commission's regulation for implementing the Colorado River salinity standards through the discharge permit program which became effective in May of 1978. One new and seven reissued industrial permits incorporated salinity monitoring requirements during 1982. Nine re-issued municipal permits incorporated salinity monitoring requirements during the reporting year.

Nevada - The State has been delegated authority to issue NPDES Permits. Water quality standards for Las Vegas Wash and Lake Mead were adopted by the State Environmental Commission in September, 1982, and approved by EPA in December, 1982. An NPDES permit has been issued to Clark County specifying effluent limits from the County sewage treatment plant. These limits are intended to assure that the standards will be met. The permit also requires limits on salinity to minimize salt discharges.

A similar permit was prepared for the City of Las Vegas, however, its issuance has been delayed because of several questions raised by the City. A public hearing was held June 8-11, 1983 to allow argument of the issues. The principal issues which remain unresolved are the permit limitations on flow and phosphorous and the requirement for the City to develop and maintain a water quality monitoring program. The next public hearing has not been scheduled.

New Mexico - Authority for issuing permits has not been granted to the State and the program is being administered by EPA, Region VI. EPA is following the Forum policy in the administration of the permit program. In the Colorado River Basin within the state, the following industrial permits have been issued: Electric Power - 3; Coal mines - 3; Uranium mines - 8; and Gravel plants - 4. All permits are consistent with the Forum's policy regarding salt discharge.

EPA has determined that discharges covered by the uranium mine permits will contribute less than 350 tons of salt per year to the nearest perennial stream segment of the Colorado River.

Municipal discharge permits have been issued for three major and two minor sewage treatment plants, two water treatment plants, and a small domestic sewage system. Forum policy will be followed in the issuance of new or reissued permits.

Utah - In accordance with the State EPA Agreement, the state of Utah drafts most municipal permits and all minor industrial permits. After Public Notice and State certification EPA issues all NPDES permits. Seven municipal permits in the Colorado River Basin (St. George, Green River, Manila Huntington, Altamont, Kanab, Ferron) were reissued during the year ending September 30, 1983. St. George is required to monitor and submit information on the sources of salinity in their system. Green River, Manila, Huntington and Ferron have less than 400 mg/l incremental increase in TDS and/or discharge less than one ton of salt per day. Therefore they are only required to monitor the intake water supply and discharge in accordance with Forum policy. Kanab, East Carbon City and Hurricane have recently completed total containment facilities eliminating their discharges. These latter two municipalities no longer have NPDES permits resulting in their permit files being deactivated. Altamont also has a total containment lagoon system.

There were 24 industrial NPDES permit issued during this report period. All dischargers were required to comply with the 1977 Forum Policy. Most of the permits are discharges of less than one ton of salt per day. Ten of the permits were for mining operations and 8 were for discharges from oil well operations. One mine and two oil wells discharge more than 1 ton of salt/day. Information submitted previously indicates that the costs to eliminate the discharges are greater than the expected downstream damage. The discharge permits for these facilities are reviewed periodically to determine their potential for salt reduction. Permit limitations for a power plant, sand and gravel operation, and two water treatment plants require "no discharge".

Wyoming - The Wyoming Department of Environmental Quality, Water Quality Division, has been granted authority for state administration of the NPDES permit program. The

Forum Policy for Implementation of the Colorado River Salinity Standards through the NPDES Permit Program is followed in the issuance of all NPDES permits. The objective of this policy for industrial discharges is no salt return whenever practicable.

In December of 1982, a conditional discharge permit was issued to Pacific Power and Light Company for the Jim Bridger Power Plant, located in Sweetwater County, Wyoming. The permit was conditioned on the salt load reaching the Green River being less than one ton per day or 350 tons per year, whichever is less, as prescribed in the Forum Policy. The entire discharge will be eliminated by 1990 as air pollution control devices are installed in 1986, 1988, and 1990.

Water Quality
Management Plans

The States have developed water quality management plans to conform with the requirements of Section 208 of the Clean Water Act. The status of the plans are summarized as follows:

Arizona - The Northern Arizona Council of Governments (NACOG) generated water quality management plans for the Colorado River and its tributaries in the northeast and north central parts of the state, while the District IV Council of Governments developed similar management plans for Mohave and Yuma Counties. The two areawide plans and the state 208 plan were conditionally approved by EPA in February and September

1979, respectively, and approved by EPA in May 1981. The plans were subsequently amended without change in salinity control provisions. Agricultural best management practices and implementation of the policy for industrial uses of brackish/saline waters offer the best opportunity for salinity control and are consistent with the Forum's plan of implementation for salinity control.

California - The Water Quality Control Plan for the East Colorado River Basin, adopted by the California Regional Water Quality Control Board and the State Water Resources Control Board in 1975, is being updated. A public hearing on the updated plan was conducted in July 1981. The salinity control component of the water quality plan is consistent with Forum's plan of implementation for salinity control. The Regional Water Quality Control Board is working with the Forum and local entities to insure that implementation of the water quality plan is achieved.

Colorado - In the Colorado River portion of the state, 208 plans have been submitted and certified for three of the four regions. Plans for the two non-designated regions in the San Juan area and the Gunnison - Uncompaghre area, were updated and recertified.

Nevada - The Clark County Department of Comprehensive Planning has submitted an amendment for the Laughlin section of the plan. Amendments regarding storm water and ground water activities are pending completion of studies. Due to unresolved issues regarding waste water treatment requirements and water quality standards for Las Vegas Wash and Lake Mead, the Cities of Las Vegas and North Las Vegas brought suit against Clark County, the State of Nevada, and the Environmental Protection Agency (EPA) resulting in a Consent Decree which was entered in March, 1979. A dispute between the parties in 1981 as to compliance with the provisions of the Consent Decree arose and an amended Consent Decree was proposed. However, the original consent Decree was retained.

Through processes set up by the Consent Decree a water quality standard study was made to determine if former water quality standards were adequate or should be revised. On December 19, 1982, EPA approved revised water quality standards for Las Vegas Wash and Lake Mead which had been adopted by the State Environmental Commission in September 1982. The State and EPA determined that these standards were sufficient to meet the requirements of the Clean Water Act. It is the opinion of EPA that the intent of the original Consent Decree has been satisfied and EPA is taking action to dismiss the original and subsequent lawsuits.

New Mexico - The Section 208 program in New Mexico is under the direction of the New Mexico Water Quality Control Commission. The State of New Mexico Water Quality Management Plan was initially adopted by the Commission in 1978 and 1979. It has been updated three times since. The Plan identifies the San Juan River Basin in New Mexico as the one of the top four priority basins for voluntary implementation of best management practices for sediment control.

The Environmental Improvement Division, a constituent agency of the Water Quality Control Commission, brought a proposed update of the irrigated agriculture element of the Plan to a public hearing in July 1983. The update recommends the voluntary use of those practices for irrigated agriculture, recommended in the New Mexico Soil and Water Conservation Plan, that may have water quality benefits. The update also supports further research in New Mexico on water quality benefits of management practices and the providing of information to farmers through the New Mexico Cooperative Extension Service. The proposed update has been adopted by the Water Quality Control Commission and is now a part of the Water Quality Management Plan.

Utah - The three designated planning agencies in the Utah portion of the Colorado River Basin (Five County, Uinta Basin and South Eastern Utah) have developed conditionally certified water quality management plans. In addition, the Wayne County portion of the Six-County Commissioners Organization (a nondesignated area) also has been conditionally certified. The update to the Five County Water Quality Management Plan is also being reviewed by the Bureau of Water Pollution Control for State certification. Improved irrigation methods and onfarm improvements are being implemented in the Uinta Basin as part of the Uintah Basin water quality management plan. The Bureau of Water Pollution Control and the Environmental Protection Agency are currently certifying the Recapture and Montezuma Creek Subbasins and the Non-point Source (NPS) Pollution Assessment and Control Plan, as part of the Southeastern Utah Water Quality Management Plan.

The NPS Plan states that salinity is one of the major NPS problems in Southeastern Utah. Currently, the Bureau of Reclamation and the Soil Conservation Service are conducting studies to determine the sources and amounts of salinity, and the activities necessary to reduce salinity levels. The economic costs of salinity loading in the Colorado River are staggering and these agenies have been assigned the responsibility for salinity control. The primary need at the local level is for coordination of the efforts underway to insure that local concerns are being met and that efforts are not unnecessarily duplicated.

Within the NPS Plan, the Soil Conservation Districts have been identified as the primary management agencies for NPS pollution control. These agencies operate at the local level and have the responsibility to implement conservation goals. As local coordinators, the SCD's may effect the greatest improvements in the local environment. This plan identifies the districts as implementors and recommends methods to improve their capability and effectiveness in implementing the recommendations. The SCD's may and should become the main contact at the local level concerning resource conservation and development. Given a structure and process from which to operate the goals of this plan and other natural resource opportunities will be more fully realized. The main recommendation of this plan is that the water quality management agency work with the SCD's to improve their involvement in natural resource issues.

Wyoming - The Water Quality Management planning program in Wyoming is under the direction of the Water Quality Division of the Department of Environmental Quality. The Clean Water Report for Southwestern Wyoming addresses water quality in Lincoln, Uinta, and Sweetwater Counties. This report was adopted at the local level, certified by the Governor, and conditionally approved by the EPA on October 9, 1980. The Governor's certification recognizes a salinity control program for the Green River Basin as a major water quality priority. The report recommends continuation of the big Sandy River Unit Study, improved irrigation efficiencies and further study of a number of other management alternatives.

The Statewide Water Quality Management Plan establishes an institutional framework under which planning and implementation activities can proceed in Wyoming. Implementation of much of the program depends on the availability of funds and the acceptance of responsibilities by the designated management agencies. Management agency agreements have been developed and are presently being implemented with the BLM, State Engineer, and the Wyoming Conservation Commission.

Other Activities

Arizona Arizona continues to participate and support the Forum in Colorado River salinity issues and programs.

The State Water Quality Control Council (WQCC) has adopted the 1981 Review of the Water Quality Standards for Salinity, Colorado River System, including the plan of implementation as part of its water quality regulations. The State has also adopted the Forum's policy for use of brackish or saline waters for industrial purposes and encourages the use of such waters for industrial purposes where feasible.

The WQCC has instituted a new stream quality category called "unique waters," by so designating the West Fork of the Little Colorado River. A stream so nominated is to be kept at pristine, extra-high quality, primarily by administrative programs.

The Soil Conservation Service is continuing a study on the Colorado River Indian Reservation aimed at improving water use efficiency through delivery system improvements and onfarm practices.

California - California continues to support the Forum as it has done since its creation on salinity issues. The requirements imposed on the NPDES permits issued are more stringent than those recommended by the Forum. The Water Quality Management Plan for the Colorado River portion of the state is consistent with the Forum's plan for salinity control and urges and supports salinity control activities.

A policy establishing priorities for the use of poor quality waters for cooling of inland power plants has been in effect since 1975. The State Water Resources Control Board has included salinity control in the Colorado River among its top priority items.

Colorado - Additional activities included coordination among the several state entities involved in the salinity control program, coordination of state efforts to gain passage of the Forum's proposed amendments to P.L. 93-320, review of the water rights issues associated with the federal salinity projects, and participation in the water quantity and quality monitoring programs for the Grand Valley and Lower Gunnison areas.

Nevada - In an effort to beneficially use saline flows in the Virgin River, the State has elicited local interest in exploring the use of this water for cooling purposes for future power generating stations. The State is also coordinating the planning efforts of the Bureau of Reclamation on the Las Vegas Wash Unit with the local entities in an effort to gain their endorsement of the project. The State of Nevada continues to support the Colorado River Basin Salinity Control Program.

New Mexico - The State of New Mexico through the Forum Member, Advisory Council members, and the New Mexico Water Quality Control Commission support the Colorado River Basin Salinity Control Program and are taking all reasonable action to insure its implementation. State actions include: (1) support of federal legislation including appropriations to implement the program, (2) inclusion of salinity control measures in the 208 plans, (3) dissemination of information on salinity sources and control measures to the water users and the public in the Colorado River Basin area of the state, (4) consultation with industries on potential salinity reduction measures, (5) implementation of Forum's Policy through existing legal and institutional mechanisms, e.g. NPDES, (6) the support of future funding for the Forum executive director whose major function is to assist in carrying out the Colorado River Salinity program, (7) allocation of state financial and manpower resources to several salinity research efforts, (8) providing matching funds to support the USGS water quality data collection program in the Colorado River Basin portion of the state which is necessary to monitor salinity conditions on the river, and (9) maintaining a continuous water quality planning program whereby new or additional salinity control measures can be addressed.

Utah - Farmers and ranchers in Utah are becoming increasingly aware of the impacts of agricultural activities on salinity and The Utah Department of Agriculture is supporting effects to reduce salt loading from agricultural activities. The Department recognizes that these actions must be accomplished at the grass roots level and the Department utilizes the local soil conservation districts, which are designated as management agencies to develop and implement plans for salinity control.

In 1983 the State of Utah created the Agriculture Resource Development Loan fund which provides low interest loans to farmers and ranchers for soil and water conservation practices. Projects are approved by local soil conservation districts based on local conservation needs. In eastern Utah these funds are being utilized to match Agriculture Conservation Project grants and to improve rangelands. The Utah Department of Agriculture maintains administrative control over the loan program; however, project approval and monitoring occurs at the local level. Reduction of salinity is a main target in certain districts.

The soil conservation districts have also been active in promoting and coordinating salinity control measures in eastern Utah. The Department is supporting these activities by providing direct technical assistance and funding support for a regional coordinator to assist in implementing district projects. The Department maintains communication with the various agencies involved in salinity control and attempts to coordinate its activities whenever possible.

The Utah Department of Agriculture is providing funding support to the Utah State University Extension Service to conduct a water management program in the state. The Uinta Basin has been identified as one of three areas in the state for implementation of this program. The program provides farmers with a management system which will minimize overwatering and thereby reduce salinity concentrations from deep percolation.

Seven salinity stations are monitored by the Utah Bureau of Water Pollution Control. Temperature and conductivity measurements are recorded every 30 minutes.

Wyoming - In 1981 the Governor's office began an active search for industrial users for the Big Sandy water. The Chevron Chemical Company has contracted to accept a portion of the Big Sandy water as a part of the water supply for its proposed Phosphate Fertilizer Plant near Rock Springs, Wyoming. Other industries in the area are seriously considering the use of such water, and negotiations are continuing. The water obtained from the Big Sandy Unit can be used in conjunction with good quality water purchased from Wyoming's nearby Fontenelle Reservoir storage when necessary to meet either quality or quantity conditions.

The joint effort between the State of Wyoming, Reclamation and the USDA is expected to reduce the TDS concentration at Imperial Dam by 7-9 mg/l upon implementation of the full project.

Forum Activities

Water Rights

The Forum Work Group appointed a committee to explore the water rights and interstate compact issues which may be raised by salinity control projects. The Work Group discussed these issues at several meetings in 1982 and recommended to the Forum at its October meeting that the following procedure be followed in dealing with the issues raised by the salinity control projects:

The water rights issues shall be addressed on a project-by-project basis with the understanding that:

1) the actions taken with respect to one project shall not establish precedents with respect to other projects, and
2) any water consumed would not necessarily be chargeable to the compact entitlement of the state in which the depletion occurs.

Baseline Values

Baseline values, which are relationships between salt load and flow, were developed for thirteen stations in the Colorado River Basin. (A description of the methodology for developing these values and the values themselves can be found in the baseline value report adopted by the Forum September 11, 1980). Preliminary values for the average annual salinity concentration at each station were developed by the USBR for the 1982 water year and compared to the baseline values. All fell within the two standard deviations of variation.

Public Involvement and Participation

The seven Basin states continue to work with concerned agencies to increase public awareness and understanding of salinity and its impacts, and will coordinate this effort with the Forum. This Annual Progress Report is a component of this educational effort and will be distributed to interested individuals and organizations.

Meetings of the Forum and its Work Group are open to the public and all comments on its activities are considered and acted on as appropriate. The Forum and the states also provided for public involvement in the standards review process.

Forum members participated with their state 208 agencies in matters related to salinity and salinity control and will continue to do so as the need arises.

The Forum's executive director contributes to the public's understanding of the salinity problem and the salinity control program through numerous meetings, public appearances and speeches.

The Bureau of Reclamation publishes a quarterly newsletter entitled "Salinity Update" which provides current information on its activities and those of other federal agencies related to salinity control. The Forum and the states also utilize the newsletter as a means of advising the public of their activities.

Forum Proposed Legislation

Throughout 1982, the Forum took various steps in an effort to secure needed amendments to P.L. 93-320 the Colorado River Basin Salinity Control Act. However, legislative reports on Senate Bill S. 2202 were not submitted to the 97th Congress until December 1982, by which time it was too late in the session for Congressional action. Hearings on the companion House Bill, H.R. 6097 were not held.

On March 10, 1983, S. 752 was introduced into the 98th Congress by Senator Armstrong of Colorado with cosponsorship by the thirteen other Basin Senators.

The legislation introduced into the Senate, with the exception of some minor technical and editorial changes, was identical to the S. 2202 introduced into the 97th Congress in 1982. The Bill calls for the exemption of the salinity control efforts from the principles, standards, and procedures required under the Water Resources Planning Act. It instructs the Secretary of the Interior to select salinity units that have the least cost per unit of salinity reduced. It authorizes, in addition to the four authorized units in the initial legislation, six salinity control units. They are: Stage I of the Lower Gunnison Basin Unit, Colorado; the McElmo Creek Unit, Colorado; Stage I of the Uinta Basin Unit, Utah; the Palo Verde Irrigation District Unit, California; Saline Water Use and Disposal Opportunity Unit; and, the Sinbad Valley Unit, Colorado.

The legislation would further authorize the Secretary of the Interior to enter into joint ventures with non-federal entities when it is in the best interest of the United States as salinity control opportunities are identified. The Bill also allows for the replacement of some incidental wildlife values that might have been foregone as a result of the construction of salinity control units. The legislation further authorizes a program to be carried out by the Secretary of Agriculture for onfarm irrigation improvements so that salinity returning from agricultural practices can be reduced. The agriculture portion of the legislation calls for the expenditure of approximately $200,000,000 over the next seven fiscal years and allows for a portion of the costs to be paid for by the Lower Colorado River Basin Development Fund and the Upper Colorado River Basin Fund.

On September 15 the Subcommittee on Water & Power of the Energy and Natural Resources Committee chaired by Senator Nickles of Oklahoma held a hearing on S. 752. A statement was submitted on behalf of the Forum by Governor Bruce Babbitt of Arizona. Separate statements were introduced by representatives of each of the other Basin states and from water users within the Basin. Administration testimony was presented by the Department of the Interior and the Department of Agriculture. Other federal agencies that submitted statements were the State Department, and EPA. Additional testimony was submitted by several organizations. All testimony and statements were generally supportive of the proposed legislation.

On April 27, H.R. 2790 a companion bill to S. 752 was introduced into the House of Representatives by Representative Kogovsek of Colorado. The Bill is currently cosponsored by 35 representatives from the Basin states. To date, the House has not scheduled hearings on this legislation.

~~Salinity Control Legislation -~~
Department of Agriculture

The Secretary of Agriculture, on behalf of the Administration and as a part of the FY 1984 budget request, submitted proposed USDA legislation to the Senate and House of Representatives. The legislation provides for a separate program for Colorado River salinity control under the Secretary of Agriculture and supports a separate consolidated account for salinity control.

The Administration's proposed legislation was introduced as S. 1842 and H.R. 3903 in the U.S. Senate and House of Representatives respectively. Both S. 1842 and H.R. 3903 are similiar to the Forum's proposed legislation (S. 752 and H.R. 2790) in that the bills authorize the Secretary of Agriculture to develop and implement a voluntary cooperative program for salinity control in the Colorado River.

Senator William Armstrong of Colorado, on September 14, 1983, introduced S. 1842 which would amend P.L. 93-320 by creating a separate onfarm salinity control program within USDA. Cosponsors of S. 1842 are: Senators Hatch and Garn of Utah, Senator Wilson of California, and Senator Goldwater of Arizona.

On September 15, 1983, Congressman Kika de la Garza of Texas introduced H.R. 3903 on behalf of himself and the Administration. H.R. 3903 is a bill to authorize the Secretary of Agriculture to develop and implement a coordinated agricultural conservation program in the Colorado River Basin. Unlike S. 1842, H.R. 3903 does not amend P.L. 93-320, but instead creates a separate USDA salinity control program independent of the Colorado River Salinity Control Act of 1974.

On September 20, 1983, the House Subcommittee on Conservation, Credit and Rural Development of the Committee on Agriculture, chaired by Congressman Jones of Tennesse held hearings on H.R. 3903 along with several other agricultural bills. Jack Barnett, the Executive Director of the Forum, submitted testimony on behalf of the Forum. Congressman de la Garza, Chairman of the House Committee on Agriculture testified in support of the bill and urged the subcommittee to enact the legislation. Additional supporting testimony was received from the Department of Agriculture. Hearings have not been scheduled on S. 1842.

Executive Director and Forum Office

The Forum offices are located at 106 West 500 South, Suite 101 in Bountiful, Utah, and the Forum is being served by an Executive Director and a secretary. The Executive Director and his activities are funded by the seven Basin states. The Executive Director has been actively carrying out the program of the Forum and a large part of his time has been spent working on the above legislation. Consultants have also assisted the Forum in carrying out its program.

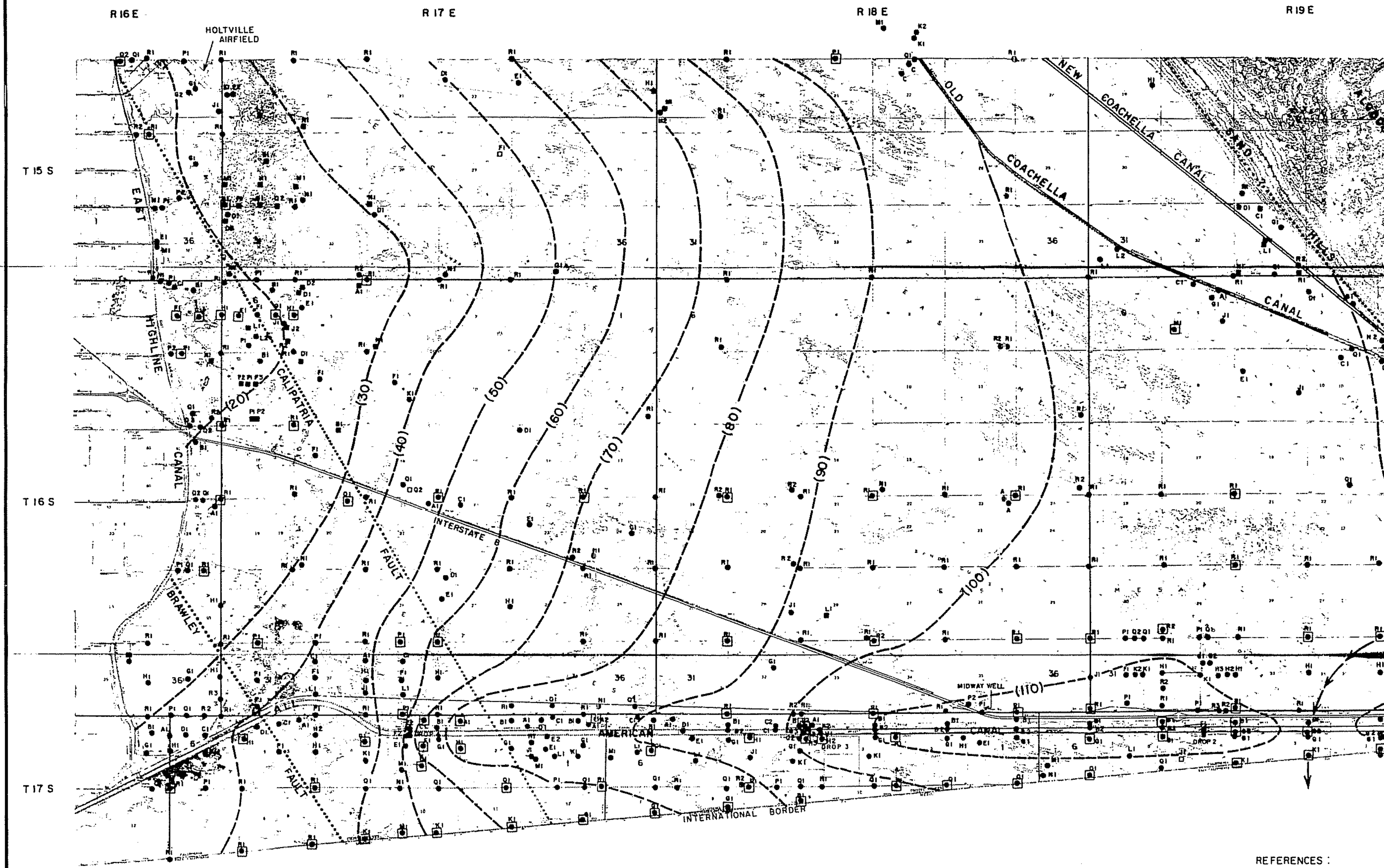
Outlook for Meeting Standards In the Future

The flow-weighted average annual salinity values at Hoover and Imperial dams increased in 1982. However, at Parker Dam, salinity decreased slightly. Based on the available data, it appears that salinity values at Hoover, Parker and Imperial Dams will decrease in 1983 as a result of river flows well in excess of water demands during the last half of 1983.

Implementation of Federal salinity control activities are continuing in the Grand Valley, Uinta Basin and Paradox Valley. However, it will be a number of years before any significant effects are felt at the three lower mainstem stations. The system's reservoir storage increased about 5.1 million acre feet as a result of higher than average runoff in 1982.

Salinity concentrations for 1982 are about 41 mg/l below the numeric criteria at Hoover Dam, 30 mg/l below the criteria at Parker Dam, and at Imperial Dam, about 54 mg/l below the numeric criteria. Considering current levels of salinity in the lower mainstem, the level of reservoir storage and the present level of water demand in the Basin, it is clear that the criteria will not be exceeded during the next twelve-month period.

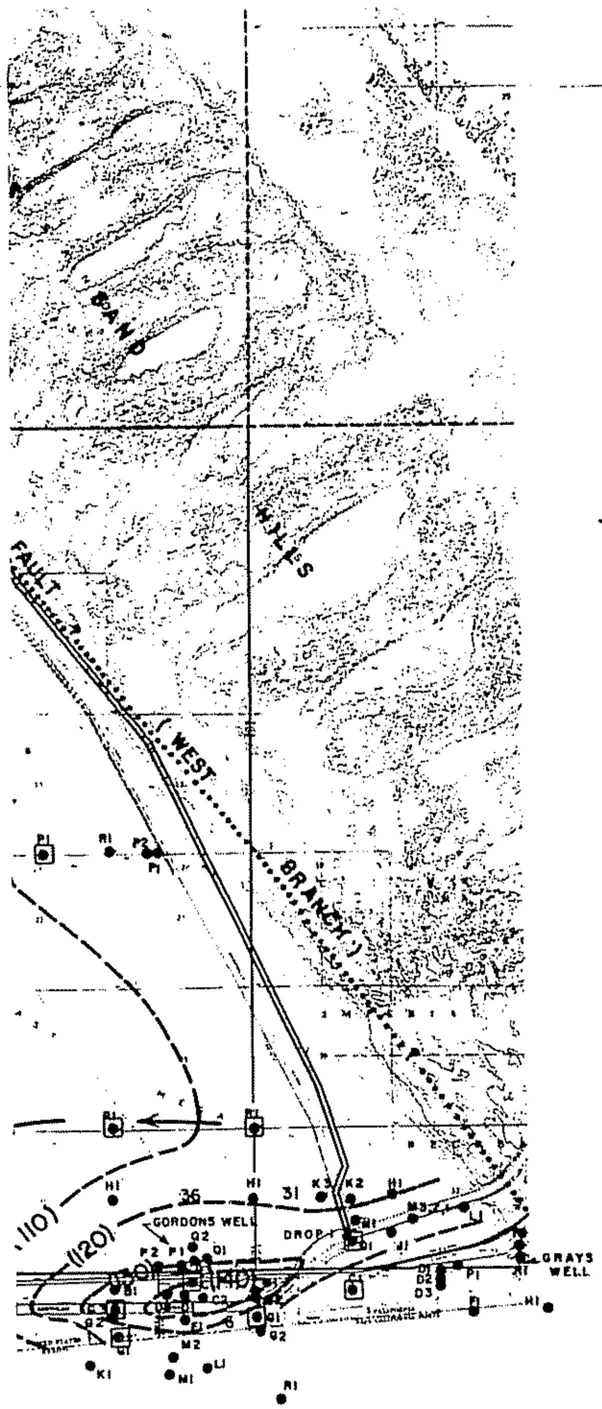
Studies by the Forum and Reclamation show that salinity concentrations will continue to increase unless salinity control measures are implemented. It takes about 10 years for the full impact of control measures to be felt at Imperial Dam. The planning and implementation of the salinity control program requires a considerable period of time. Therefore it is imperative that the salinity control program be carried out as expeditiously as possible.



REFERENCES :
BASE MAP PREPARE
TOPOGRAPHIC QUADRANG
CORNER, GLAMIS SW,
MIDWAY WELL, CACTU
FAULTS FROM MC

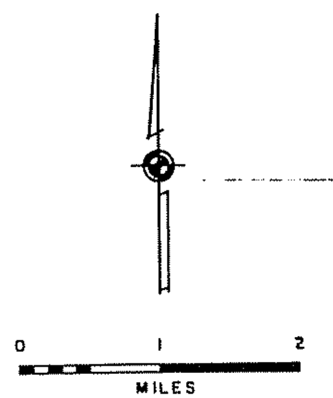
JOB E-83066 DATE 11-23-83 DR. M.G. O.E. CHKD.

R 20 E



EXPLANATION

- ● OBSERVATION WELL, WATER WELL, TEMPERATURE WELL OR TEST HOLE
- ◻ OIL OR GAS WELL OR DRILL HOLE
- ■ GEOTHERMAL WELL OR DRILL HOLE
- K1 WELL, TEST HOLE OR DRILL HOLE NUMBER
- ....?... FAULT, APPROXIMATELY LOCATED OR CONCEALED
- —— LINES OF EQUAL GROUND WATER ELEVATION, IN FEET
- ⊡ 1982 WATER LEVEL AVAILABLE FOR WELL
- ←← POSSIBLE BURIED ANCESTRAL CHANNEL OF COLORADO RIVER OR TRIBUTARY

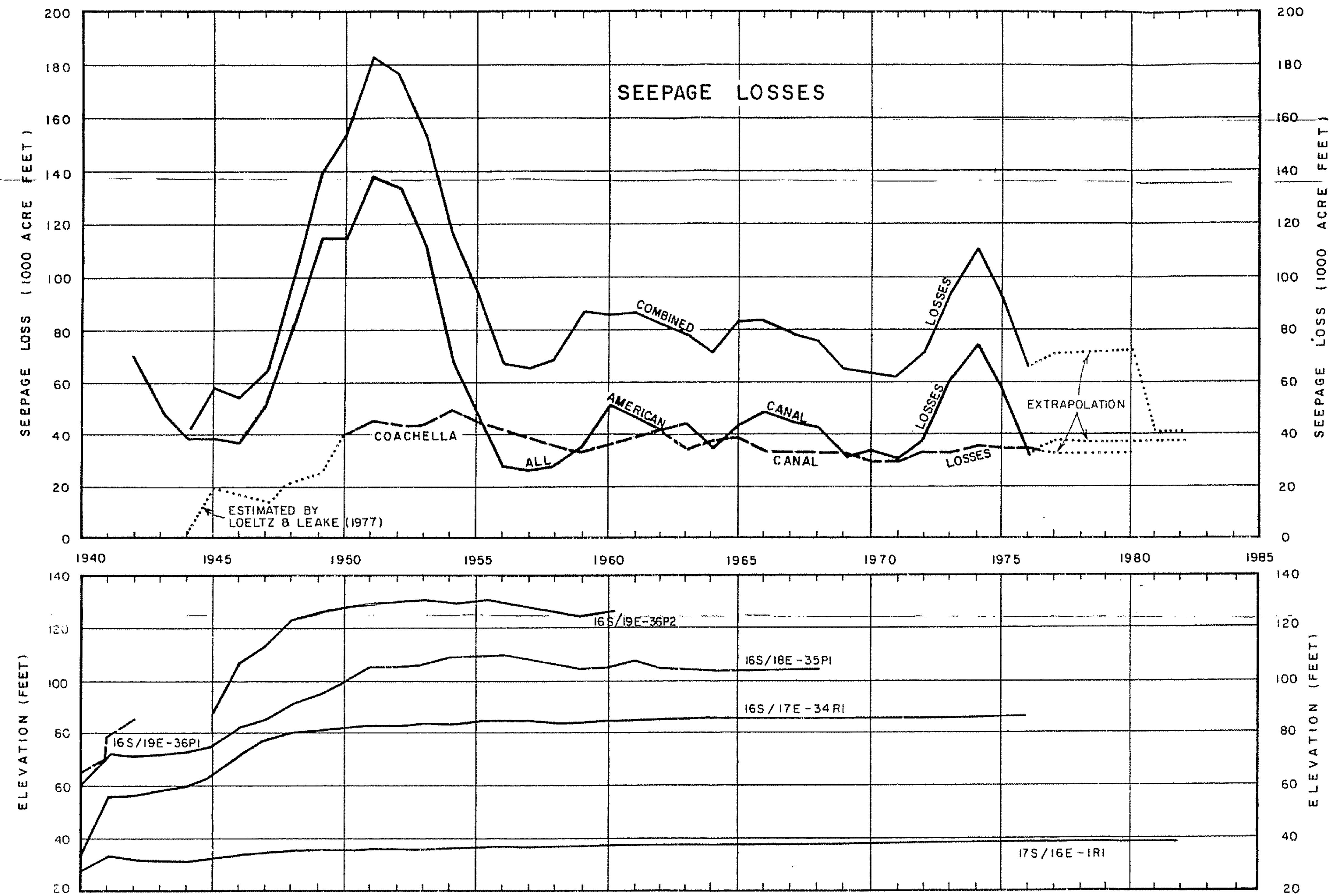


FROM U S G.S. 7½ MINUTE
:S : HOLTVILLE EAST, BONDS
DWAY WELL NW, GLAMIS SE,
, AND GRAYS WELL
TON (1977)

FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

GROUND WATER CONTOUR MAP
OCTOBER 1982

LeROY CRANDALL AND ASSOCIATES | PLATE 9



HYDROGRAPHS *

NOTES: SEEPAGE DATA OBTAINED FROM I.I.D AND LOELTZ AND LEAKE (1977)
SEE TEXT FOR EXPLANATION OF DATA BETWEEN 1944-1950 FOR COACHELLA CANAL AND BETWEEN 1976-1982 FOR BOTH CANALS.

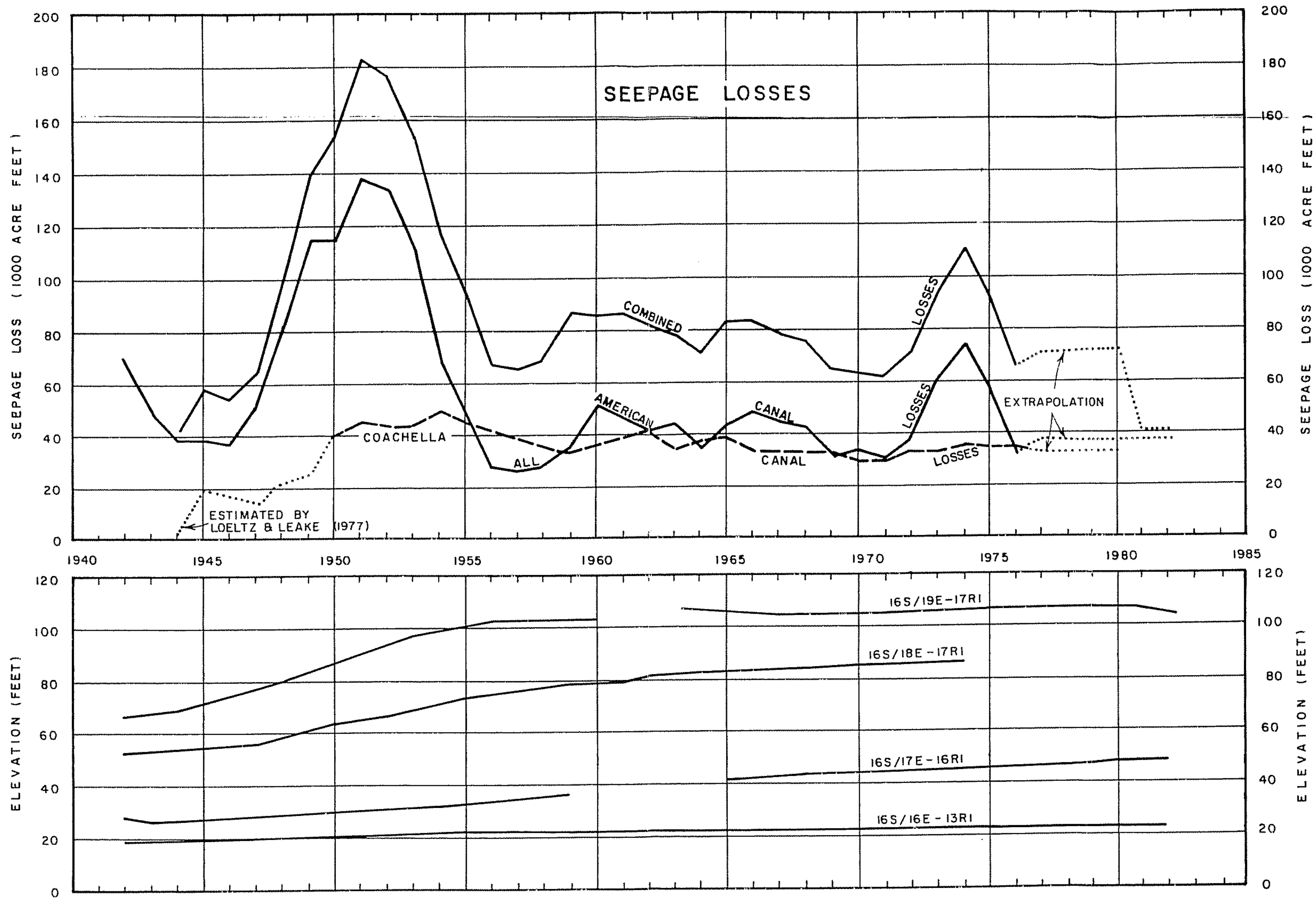
* WATER LEVEL DATA ARE FOR OCTOBER OF EACH YEAR

FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

HYDROGRAPHS

WELLS ALONG ALL AMERICAN CANAL

LeROY CRANDALL AND ASSOCIATES | PLATE 10



HYDROGRAPHS *

NOTES: SEEPAGE DATA OBTAINED FROM I.I.D. AND LOELTZ AND LEAKE (1977)
SEE TEXT FOR EXPLANATION OF DATA BETWEEN 1944-1950 FOR COACHELLA CANAL AND BETWEEN 1976-1982 FOR BOTH CANALS.

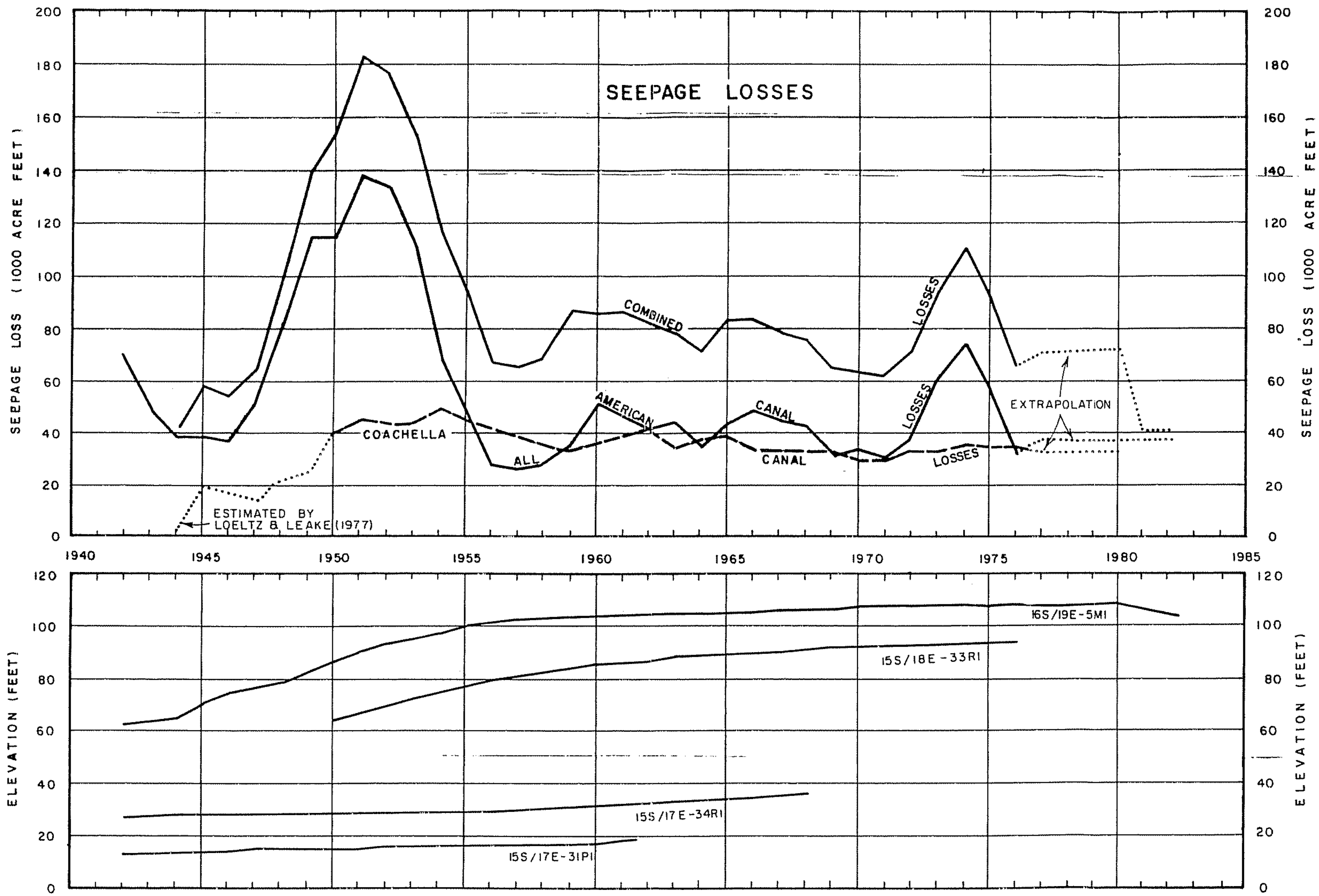
* WATER LEVEL DATA ARE FOR OCTOBER OF EACH YEAR

FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

HYDROGRAPHS

WELLS THREE MILES NORTH OF ALL AMERICAN CANAL

LeROY CRANDALL AND ASSOCIATES | PLATE II



HYDROGRAPHS *

NOTES: SEEPAGE DATA OBTAINED FROM I.I.D AND LOELTZ AND LEAKE (1977) SEE TEXT FOR EXPLANATION OF DATA BETWEEN 1944-1950 FOR COACHELLA CANAL AND BETWEEN 1976-1982 FOR BOTH CANALS.

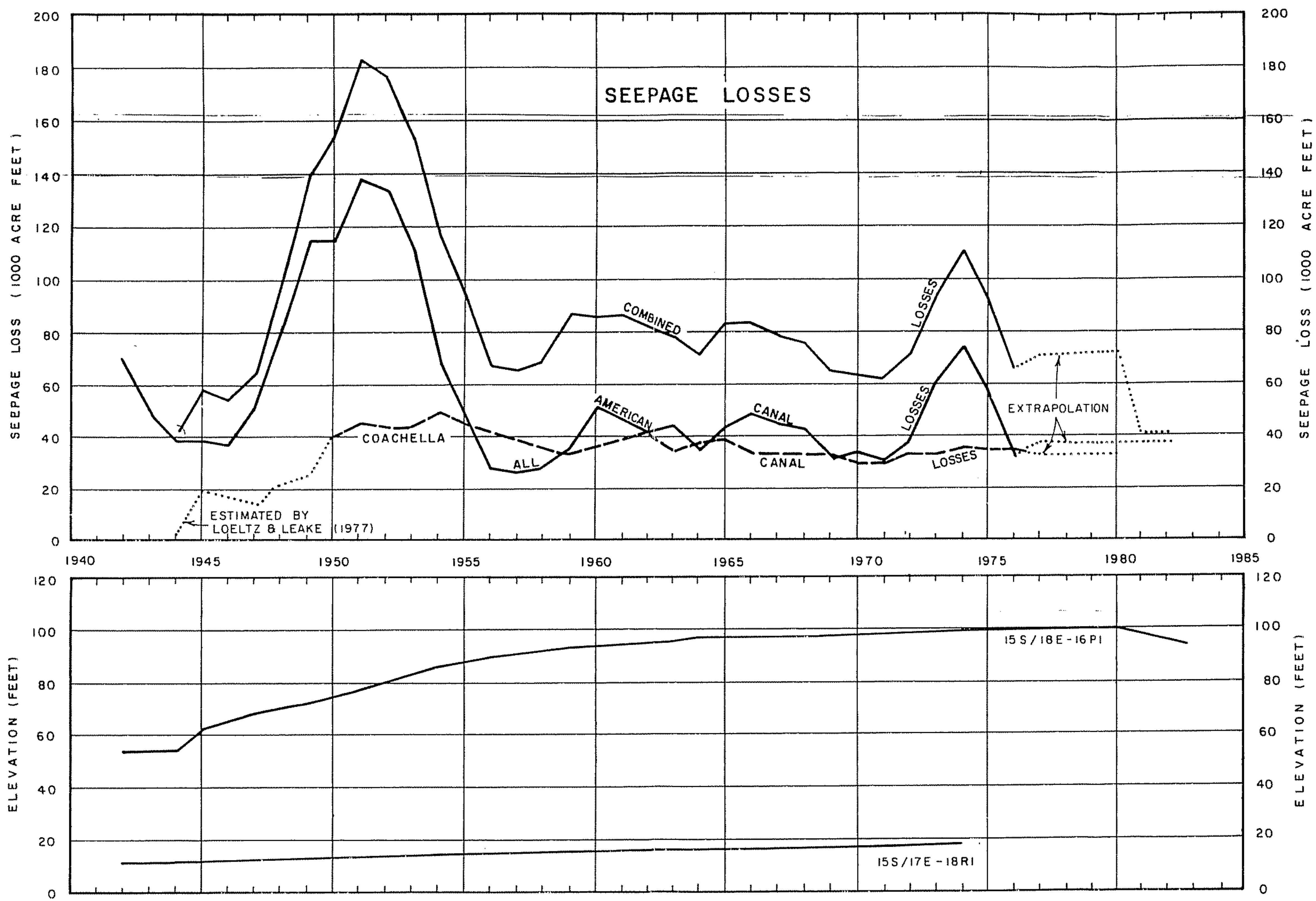
* WATER LEVEL DATA ARE FOR OCTOBER OF EACH YEAR

FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

HYDROGRAPHS

WELLS SIX MILES NORTH OF ALL AMERICAN CANAL

LeROY CRANDALL AND ASSOCIATES | PLATE 12



HYDROGRAPHS *

NOTES: SEEPAGE DATA OBTAINED FROM I.I.D AND LOELTZ AND LEAKE (1977)
SEE TEXT FOR EXPLANATION OF DATA BETWEEN 1944-1950 FOR COACHELLA CANAL AND BETWEEN 1976-1982 FOR BOTH CANALS.

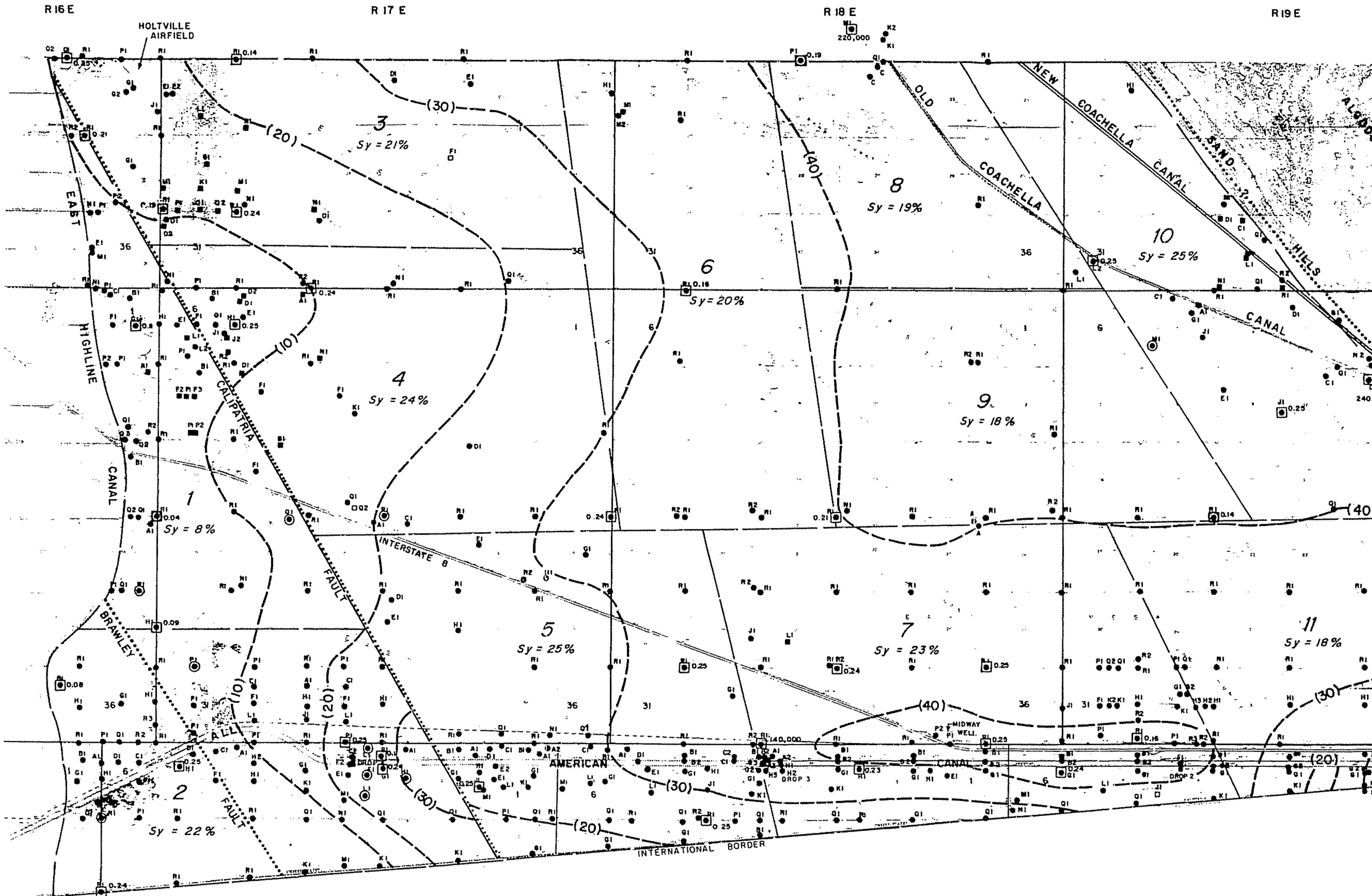
* WATER LEVEL DATA ARE FOR OCTOBER OF EACH YEAR

FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

HYDROGRAPHS

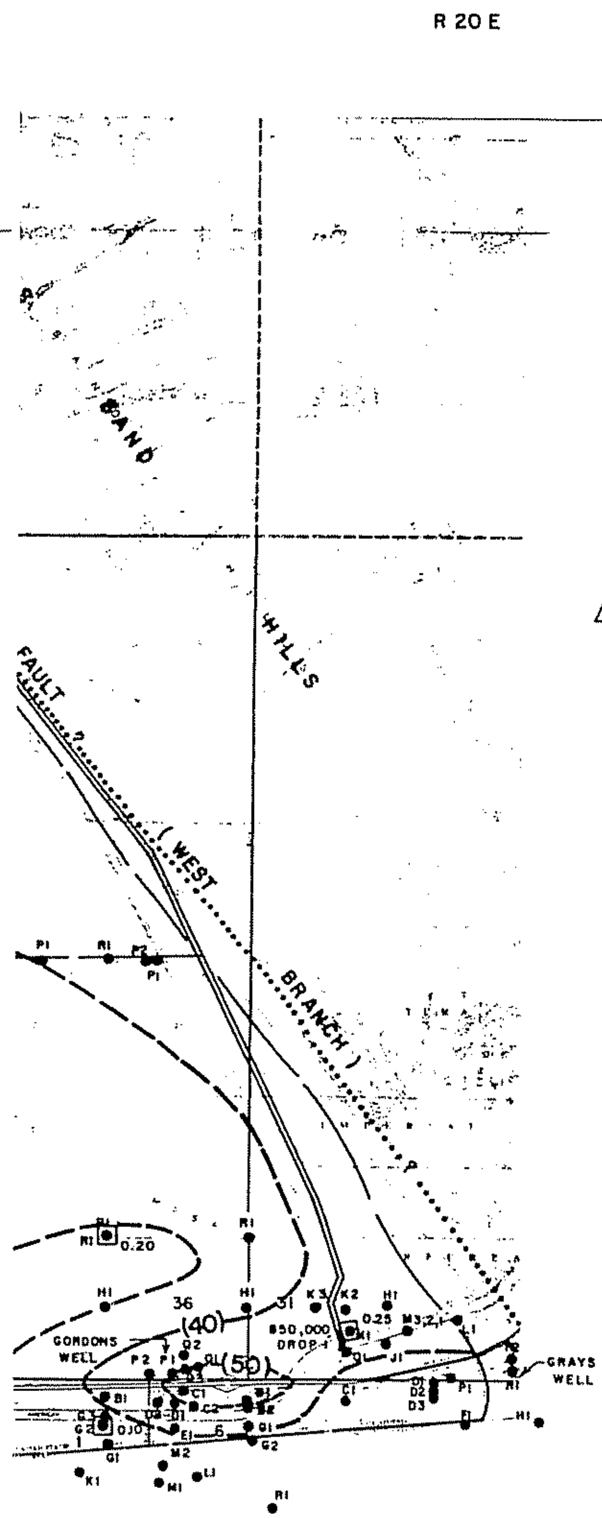
WELLS NINE MILES NORTH OF ALL AMERICAN CANAL

LeROY CRANDALL AND ASSOCIATES | PLATE 13



REFERENCES :
BASE MAP PREPAREC
TOPOGRAPHIC QUADRANGI
CORNER, GLAMIS SW, M
MIDWAY WELL , CACTUS
FAULTS FROM MO

JOB E-83066 DATE 11-23-83 DR. M.G. O.E. CHKD.



EXPLANATION

- OBSERVATION WELL, WATER WELL, TEMPERATURE WELL OR TEST HOLE
- OIL OR GAS WELL OR DRILL HOLE
- GEOTHERMAL WELL OR DRILL HOLE
- K1 — WELL, TEST HOLE OR DRILL HOLE NUMBER
- ....?... — FAULT, APPROXIMATELY LOCATED OR CONCEALED
- — — — LINES OF EQUAL RISE IN WATER LEVEL, IN FEET
- 5 — SUBAREA
- Sy = 19% — SPECIFIC YIELD OF SUBAREA
- 0.23 — SPECIFIC YIELD OF WELL FOR SELECTED WELLS
- 140,000 — TRANSMISSIBILITY (gpd/ft) OF WELL DETERMINED BY PUMP TEST
- RISE IN WATER LEVELS BETWEEN 1942 TO 1982 AVAILABLE FOR WELL

NOTE : SEE TEXT FOR EXPLANATION OF THE DERIVATION OF THE LINES OF EQUAL RISE IN WATER LEVEL

0 1 2
MILES

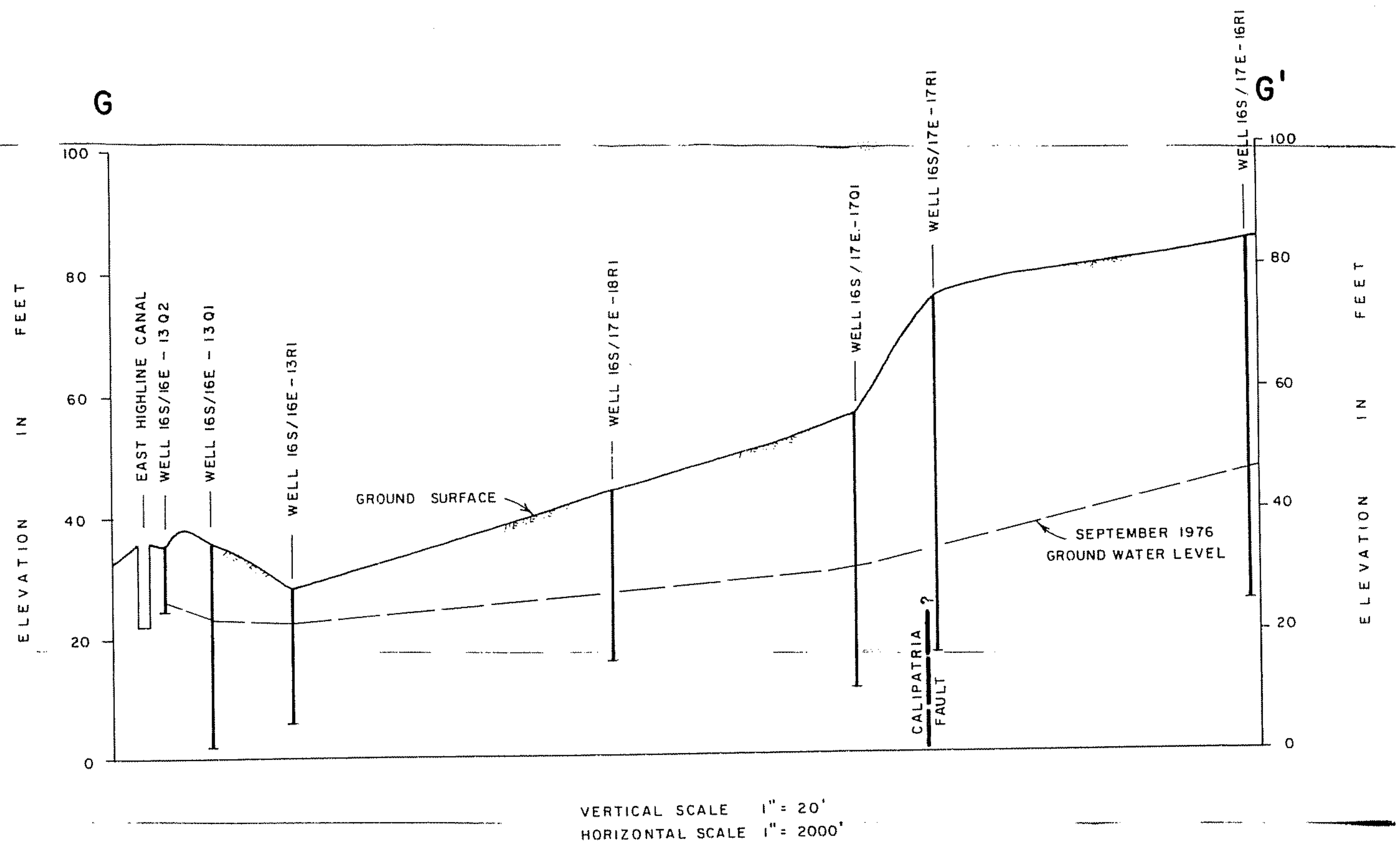
ROM U S G S 7½ MINUTE
S : HOLTVILLE EAST, BONDS
)WAY WELL NW, GLAMIS SE,
AND GRAYS WELL
ON (1977)

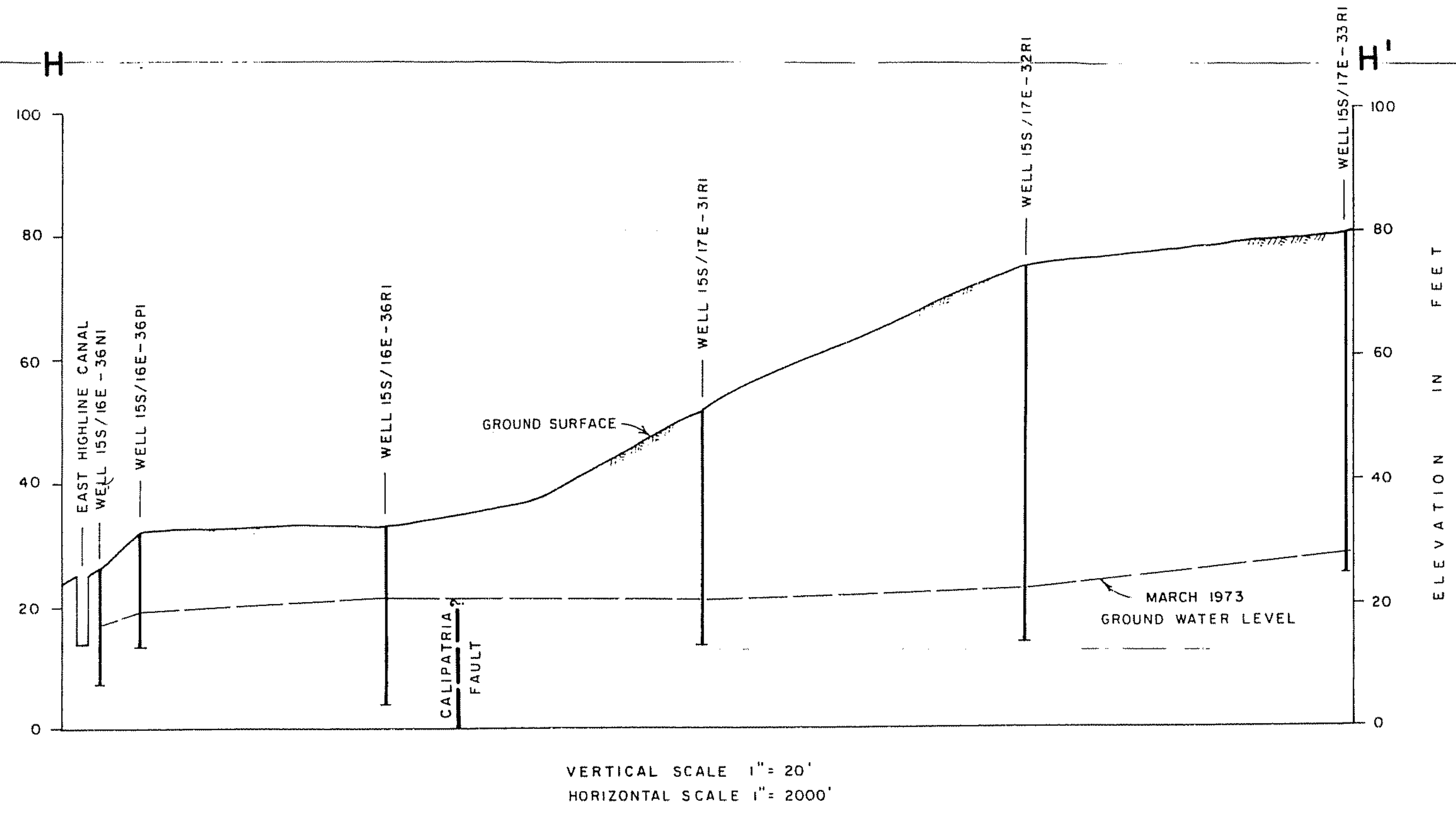
FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

RISE IN WATER LEVELS 1942 - 1982

LeROY CRANDALL AND ASSOCIATES	PLATE 14

JOB E-83066 DATE 8-1-83 DR. M.G. O.E. CHKD

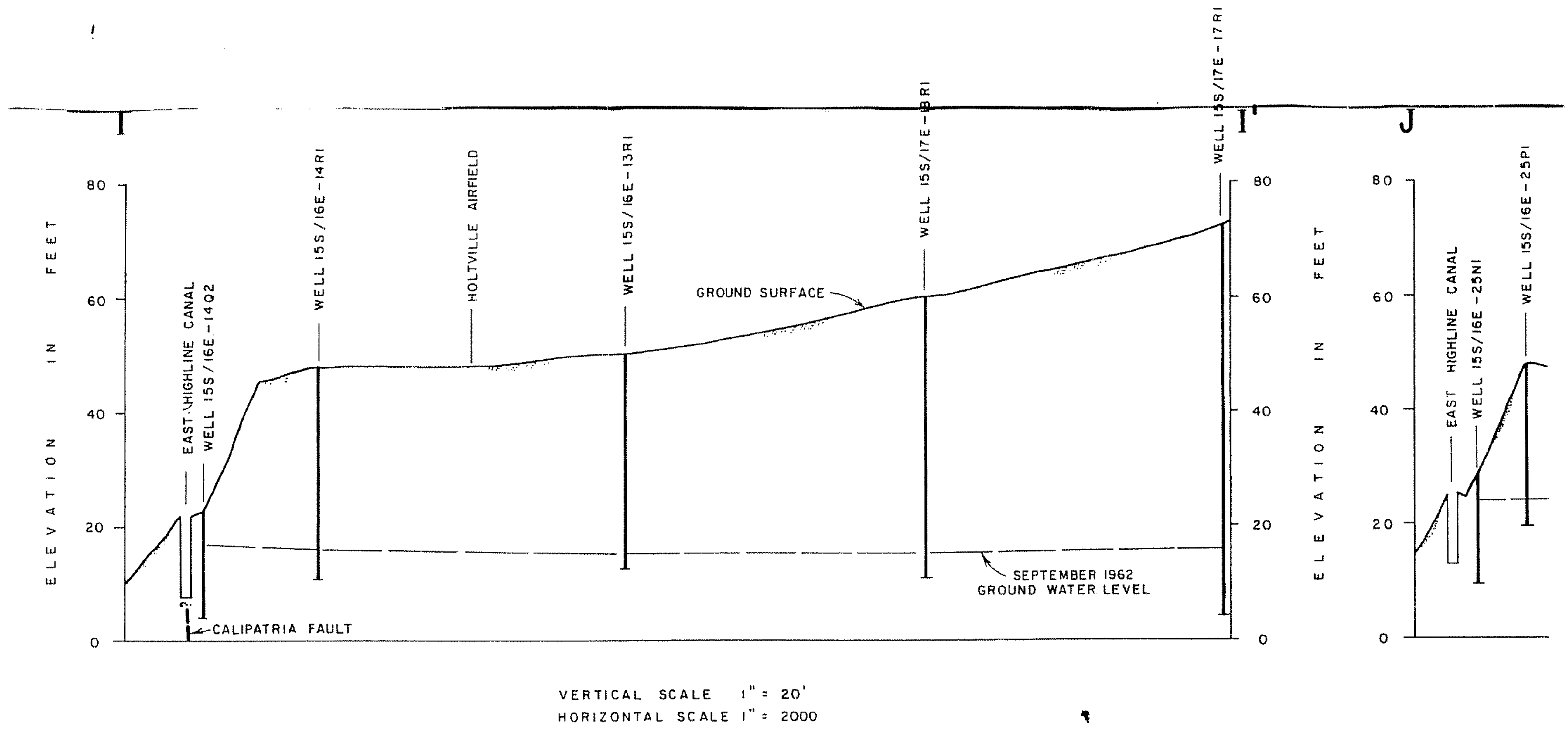




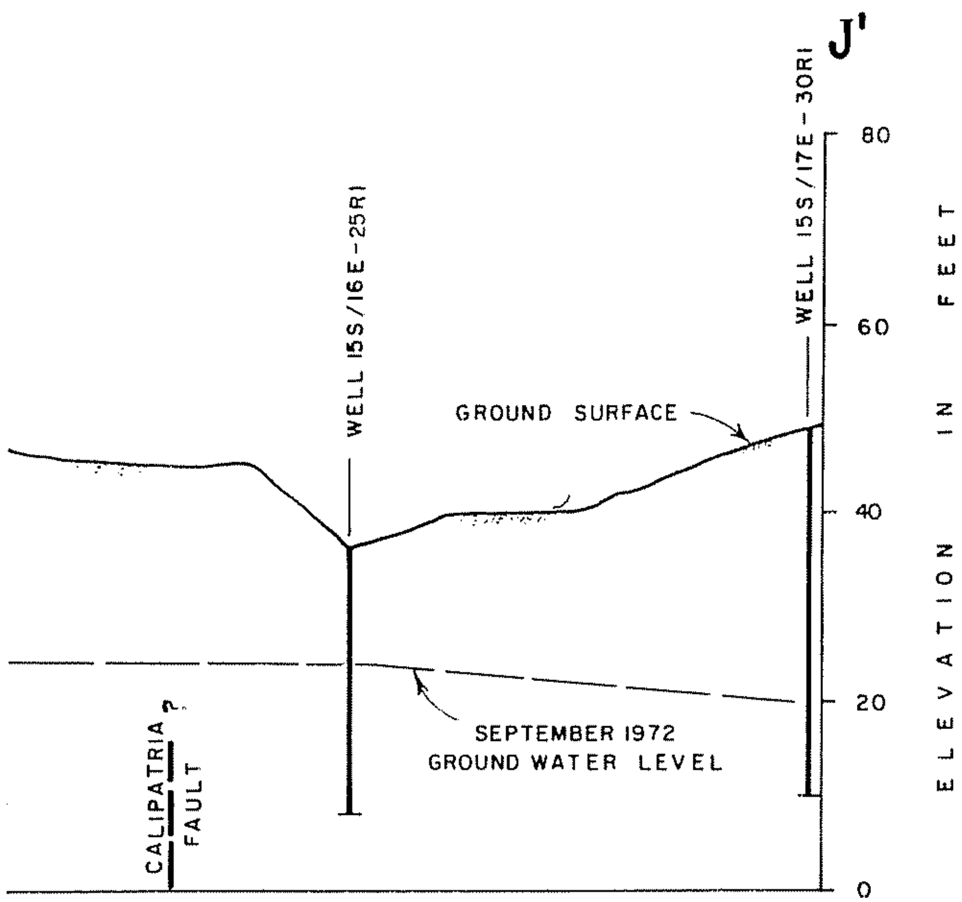
FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

CROSS SECTIONS G-G' AND H-H'

LeROY CRANDALL AND ASSOCIATES	PLATE 15



JOB E-83066 DATE 8-1-83 DR. M.G. O.E. CHKD.



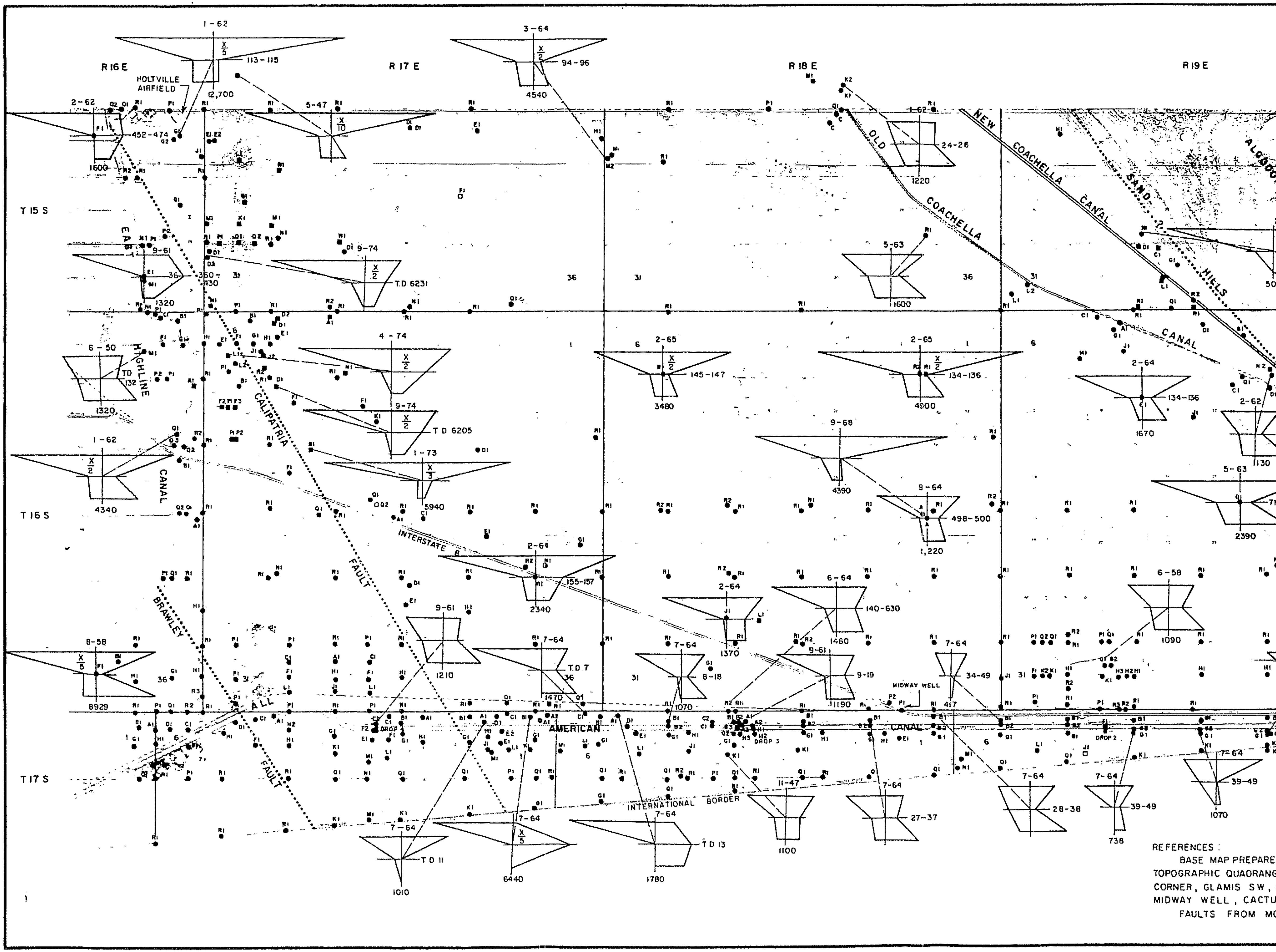
VERTICAL SCALE 1" = 20'
HORIZONTAL SCALE 1" = 2000'

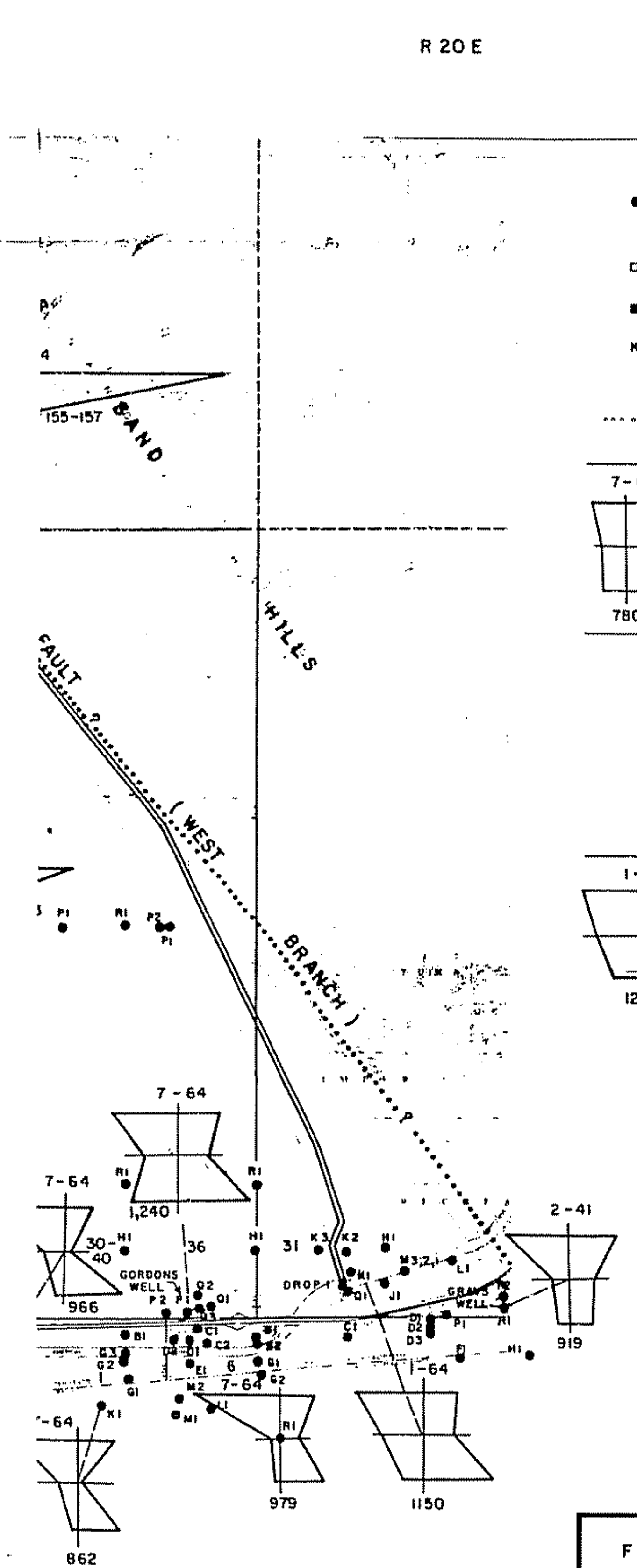
FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

CROSS SECTIONS I-I' AND J-J'

LeROY CRANDALL AND ASSOCIATES	PLATE 16

JOB E-83066 DATE 11-23-83 DR. M.G. O.E. CHKD.





FROM U S G S 7$^1/_2$ MINUTE
S . HOLTVILLE EAST, BONDS
DWAY WELL NW. GLAMIS SE,
AND GRAYS WELL
TON (1977)

EXPLANATION

- ● OBSERVATION WELL, WATER WELL, TEMPERATURE WELL OR TEST HOLE
- ▫ OIL OR GAS WELL OR DRILL HOLE
- ▪ GEOTHERMAL WELL OR DRILL HOLE
- K1 WELL, TEST HOLE OR DRILL HOLE NUMBER
- ....?... FAULT, APPROXIMATELY LOCATED OR CONCEALED

7-64 DATE SAMPLED

500 DEPTH SAMPLED OR TOTAL DEPTH (T.D.) OF WELL IN FEET

780 ELECTRICAL CONDUCTANCE IN MICROMHOS/cm

MILLIEQUIVALENT PER LITER

20 16 12 8 4 0 4 8 12 16

Na + K — Cl

Ca — HCO_3

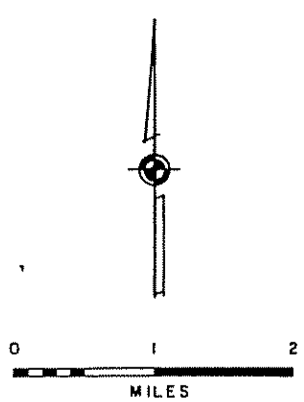
Mg — SO_4

$\frac{X}{5}$ = SCALE OF DIAGRAMS REDUCED $\frac{1}{5}$

1-81

WATER QUALITY FROM IMPERIAL DAM

1260

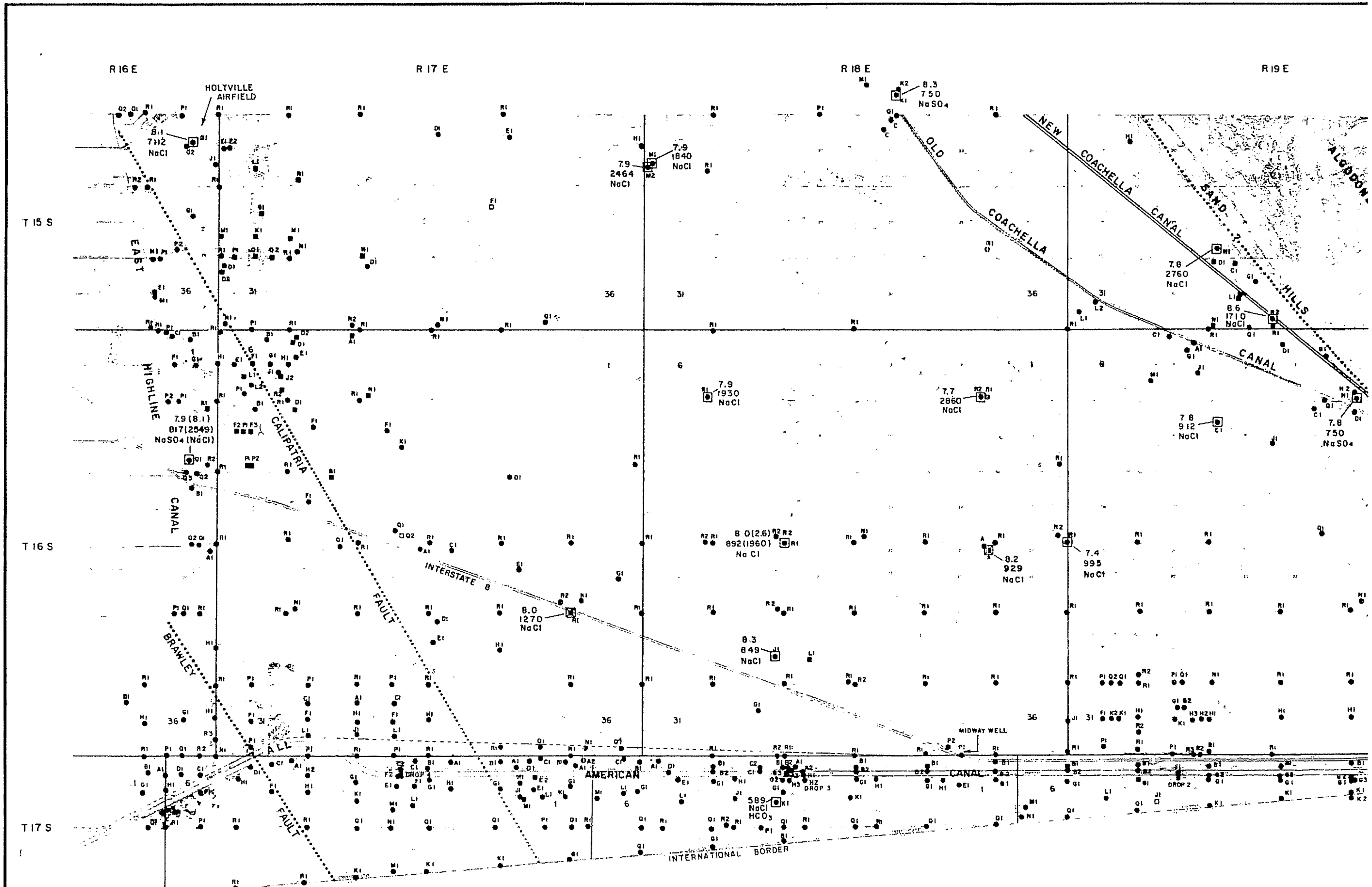


FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

CHEMICAL CHARACTER OF GROUND WATER

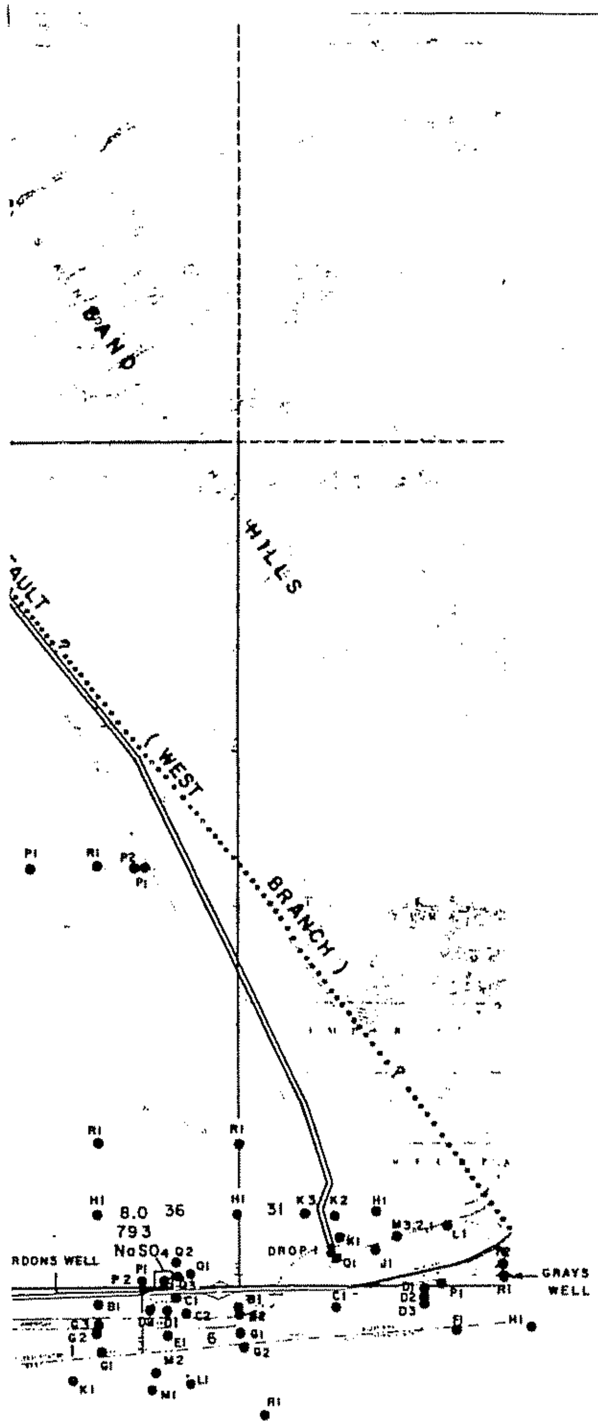
LeROY CRANDALL AND ASSOCIATES | PLATE 17

JOB E-83066 DATE 11-23-83 DR. M.G. O.E. CHKD.



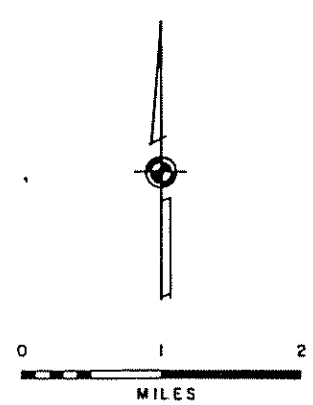
REFERENCES.
BASE MAP PREPARED
TOPOGRAPHIC QUADRANGL
CORNER, GLAMIS SW, M
MIDWAY WELL, CACTUS
FAULTS FROM MOI

R 20 E



EXPLANATION

- ● OBSERVATION WELL, WATER WELL, TEMPERATURE WELL OR TEST HOLE
- ▫ OIL OR GAS WELL OR DRILL HOLE
- ▪ GEOTHERMAL WELL OR DRILL HOLE
- K1 WELL, TEST HOLE OR DRILL HOLE NUMBER
- ....?... FAULT, APPROXIMATELY LOCATED OR CONCEALED
- 8.3 pH
- 750 TDS in ppm
- $NaSO_4$ CHEMICAL CHARACTER
- ▣ SHALLOWER INTERVAL ALSO SAMPLED
- ◘ CHEMICAL ANALYSES AND INTERVAL PERFORATED KNOWN FOR WELL

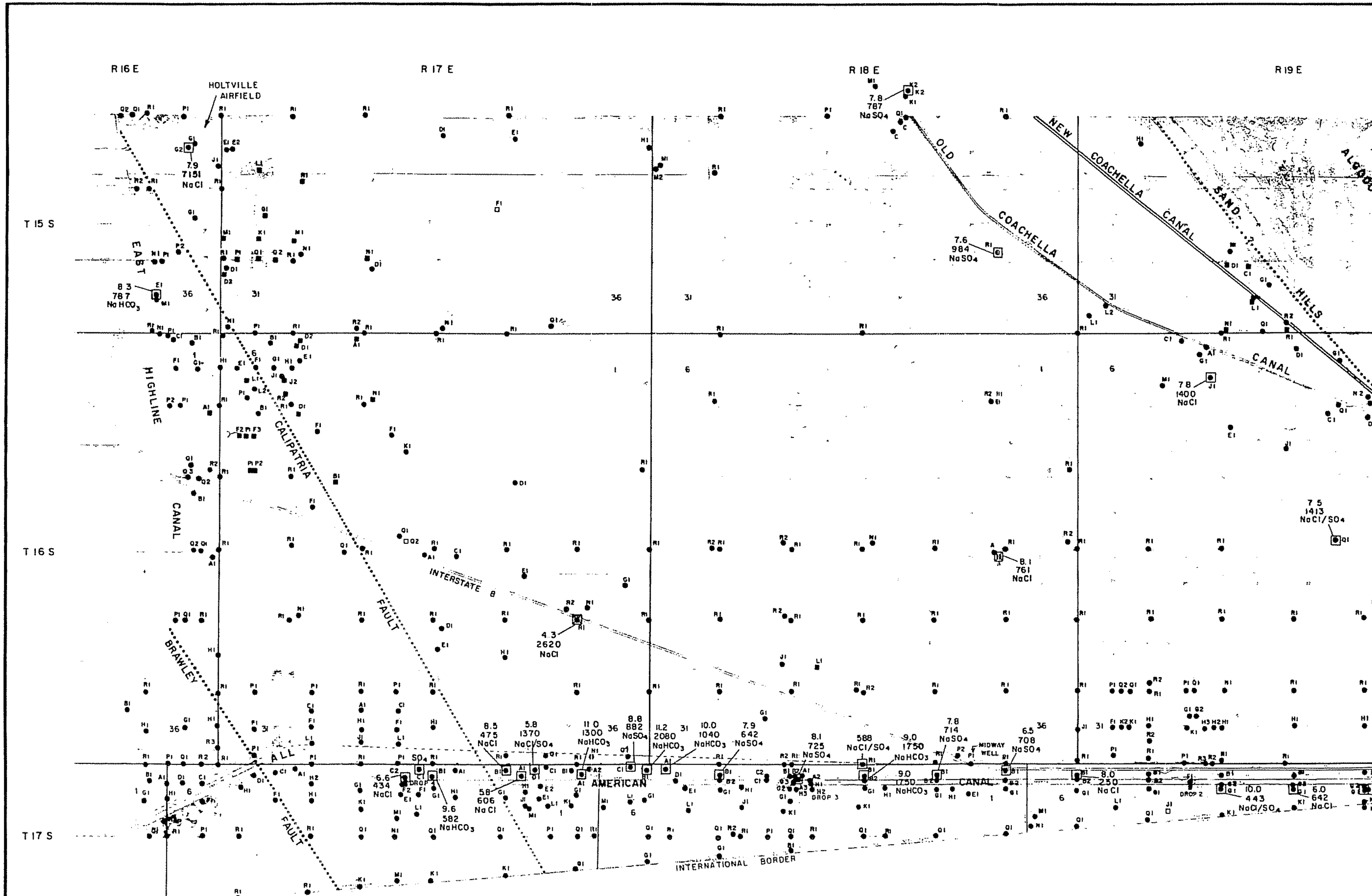


ROM U S G S 7½ MINUTE
; : HOLTVILLE EAST, BONDS
WAY WELL NW, GLAMIS SE,
AND GRAYS WELL
ON (1977)

FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

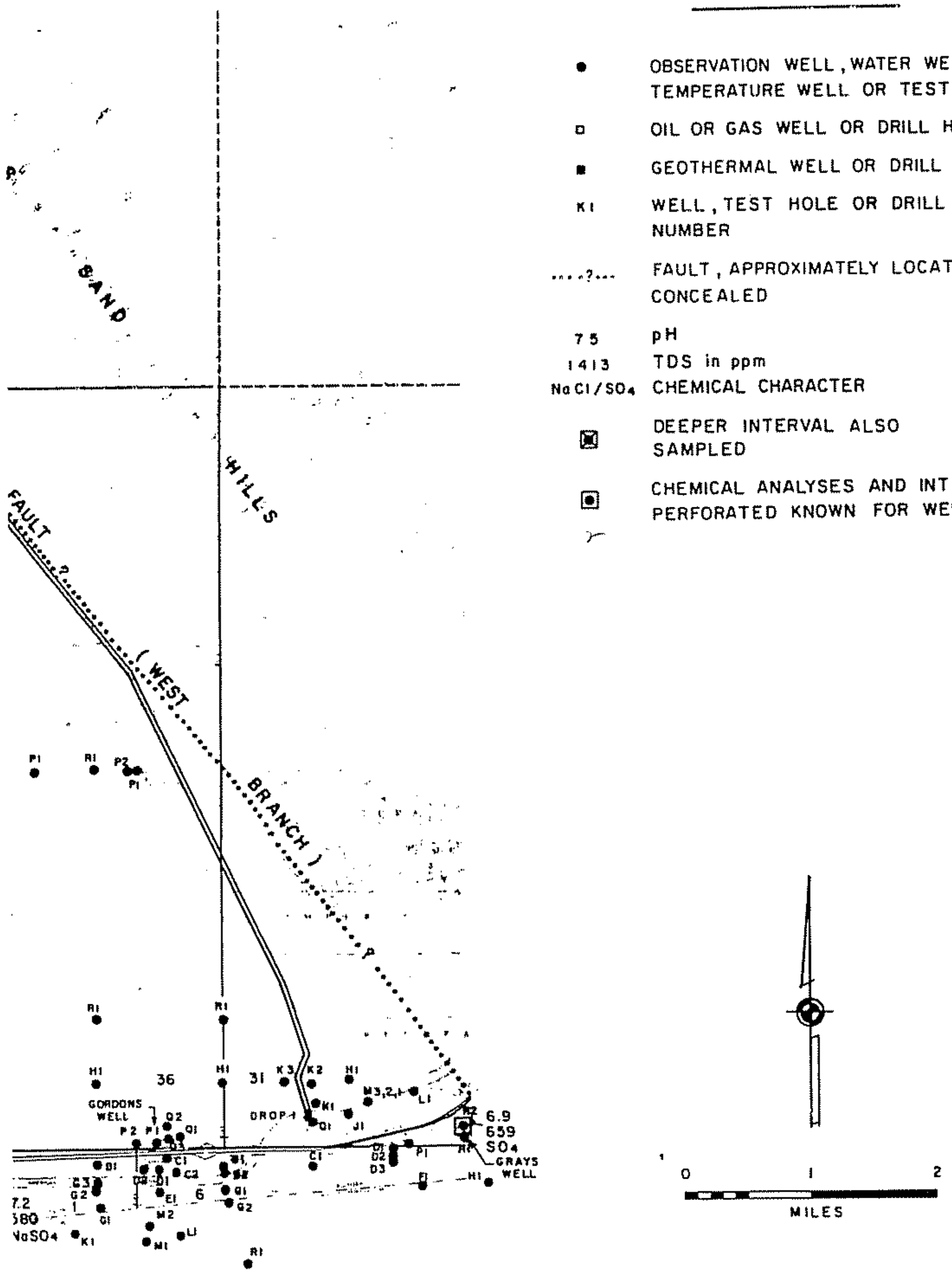
WATER QUALITY ZONE A
85-160 FEET

LeROY CRANDALL AND ASSOCIATES | PLATE 18



REFERENCES :
BASE MAP PREPARE[D]
TOPOGRAPHIC QUADRANG[LE]
CORNER, GLAMIS SW, [...]
MIDWAY WELL, CACTU[S]
FAULTS FROM MO[...]

JOB E-83066 DATE 11-23-83 DR. M.G. O.E. CHKD.



EXPLANATION

●	OBSERVATION WELL, WATER WELL, TEMPERATURE WELL OR TEST HOLE
▫	OIL OR GAS WELL OR DRILL HOLE
▪	GEOTHERMAL WELL OR DRILL HOLE
K1	WELL, TEST HOLE OR DRILL HOLE NUMBER
....?...	FAULT, APPROXIMATELY LOCATED OR CONCEALED
7.5	pH
1413	TDS in ppm
NaCl/SO4	CHEMICAL CHARACTER
⊠	DEEPER INTERVAL ALSO SAMPLED
⊡	CHEMICAL ANALYSES AND INTERVAL PERFORATED KNOWN FOR WELL

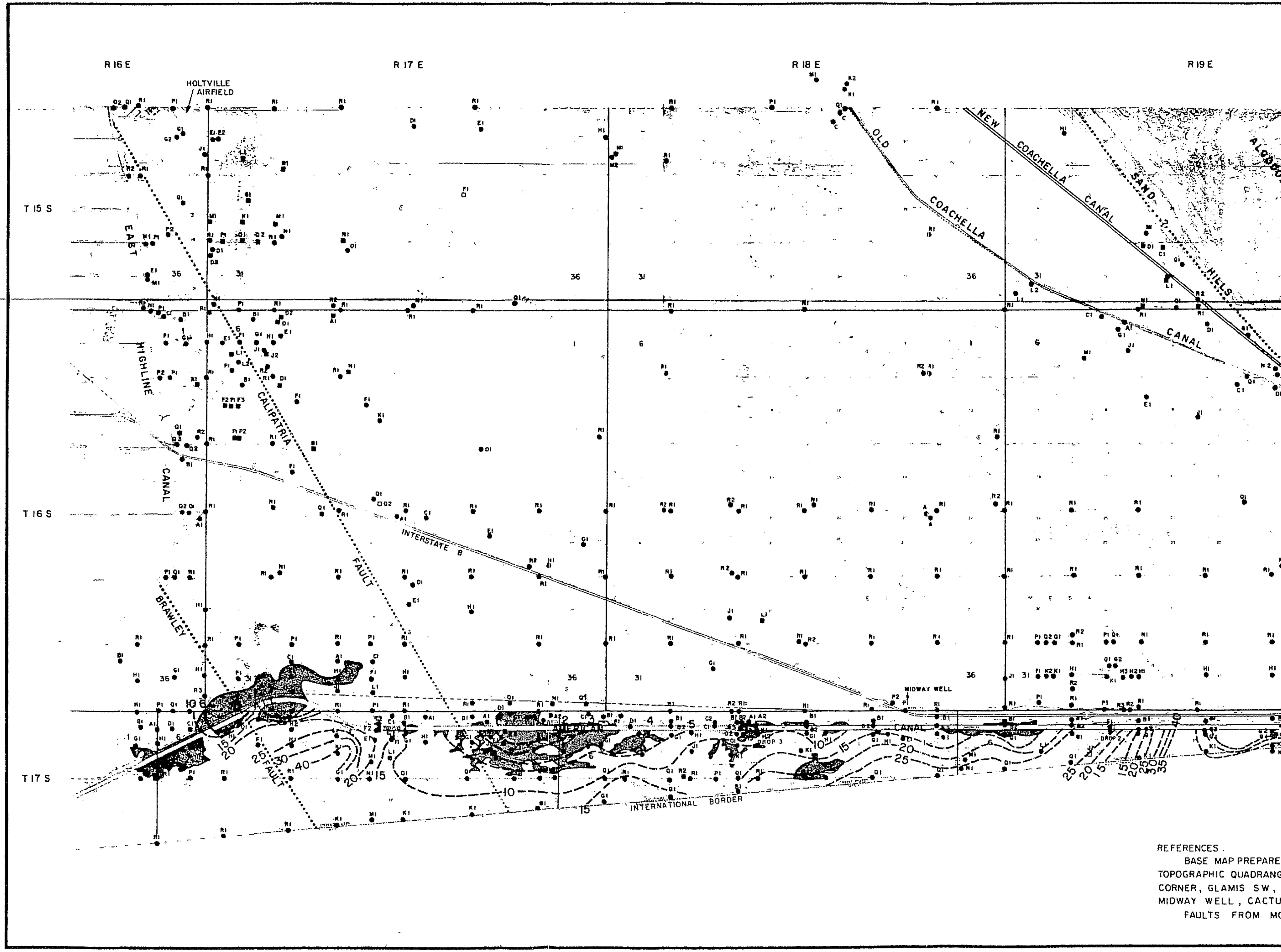
FROM USGS 7½ MINUTE
.S : HOLTVILLE EAST, BONDS
)WAY WELL NW. GLAMIS SE.
AND GRAYS WELL
TON (1977)

FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

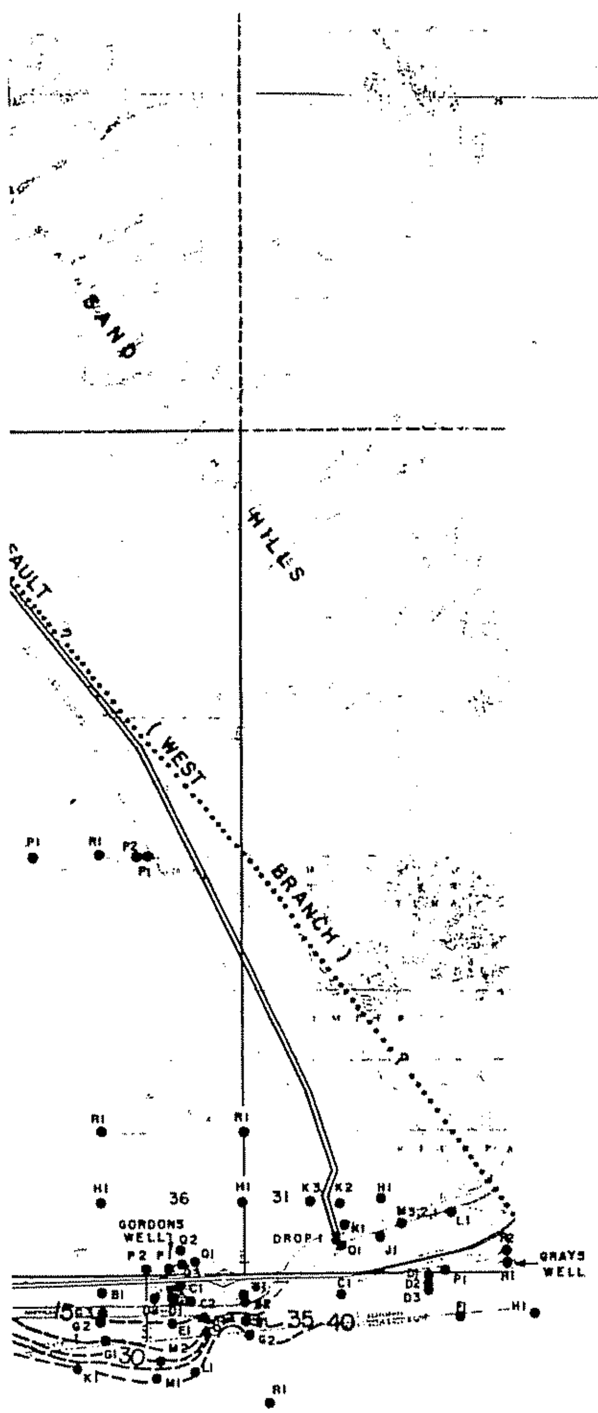
WATER QUALITY ZONE B
0-85 FEET

LeROY CRANDALL AND ASSOCIATES | PLATE 19

JOB E-83066 DATE 11-23-83 DR. M.G. O.E. CHKD.

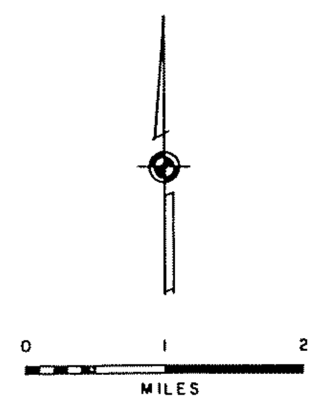


R 20 E



EXPLANATION

- OBSERVATION WELL, WATER WELL, TEMPERATURE WELL OR TEST HOLE
- OIL OR GAS WELL OR DRILL HOLE
- GEOTHERMAL WELL OR DRILL HOLE
- K1 WELL, TEST HOLE OR DRILL HOLE NUMBER
- ....?... FAULT, APPROXIMATELY LOCATED OR CONCEALED
- AREA OF PHREATOPHYTE GROWTH
- LINE OF EQUAL DEPTH TO GROUND WAT[illegible], IN FEET (1980)



ROM U S G S 7 1/2 MINUTE
S . HOLTVILLE EAST, BONDS
)WAY WELL NW, GLAMIS SE,
AND GRAYS WELL
ON (1977)

FEASIBILITY OF GROUND WATER RECOVERY
EAST MESA AREA

AREAS OF PHREATOPHYTE GROWTH, ALL AMERICAN CANAL

LeROY CRANDALL AND ASSOCIATES | PLATE 20

APPENDIX

WATER QUALITY ANALYSES

TABLE A-1
WATER QUALITY ANALYSES
EAST MESA STUDY AREA

Well Number and Depth	Date and Depth Sampled	$ECx10^6$ at 25^oC	pH	Mineral constituents in parts per million											TDS in ppm
				Ca	Mg	Na	K	$CaCO_3$	HCO_3	SO_4	Cl	NO_3	F	B	
15S/16E-23F1	2/14/62 452-474	1600	8.3	9.0	1.0	385	--	449	548	185	151	--	3.5	--	1011
15S/16E-24G1	1/16/62 50-52	12,700	7.9	238	172	2230	--	219	267	500	3840	--	--	--	7151
15S/16E-24G2	1/18/62 113-115	12,700	8.1	384	232	2010	--	240	293	217	4120	--	--	--	7112
15S/16E-36E1	7/31/61 0-10	1360	8.3	8.2	1.6	294	--	369	450	76	159	--	3.0	--	787
15S/17E-18	5/19/47	--	--	451	222	3530	--	0	55	402	6563	--	1.0	0.3	13,390
15S/17E-31D2	9/13/74	--	7.7	96	1.1	782	25	--	467	172	490	--	--	2.2	2311
15S/18E-15K1	1/18/62 134-136	1190	8.3	22	7.9	225	--	127	155	300	97	--	--	--	750
15S/18E-15K2	1/18/62 24-26	1220	7.8	8.4	32	135	--	136	166	333	109	--	--	--	787
15S/18E-19M1	1/17/62 155-157	3360	7.9	122	58	496	--	244	298	57	935	--	--	--	1840
15S/18E-19M2	3/2/64 94-96	4540	7.9	139	63	694	--	104	127	250	1240	--	0.8	--	2464
15S/18E-26R1	5/16/63 82-84	1600	7.6	87	32	204	--	--	200	317	211	--	0.7	--	984
15S/19E-28N1	2/19/64 155-157	5060	7.8	143	5.6	885	--	--	94	225	1410	--	1.9	--	2760

Well Number and Depth	Date and Depth Sampled	$ECx10^6$ at 25^oC	pH	Mineral constituents in parts per million											TDS in ppm
				Ca	Mg	Na	K	$CaCO_3$	HCO_3	SO_4	Cl	NO_3	F	B	
15S/19E-33R1	3/6/64 155-157	3180	8.6	111	10	505	--	--	98	233	775	--	1.0	--	1710
16S/16E-1M1	6/1/50	1320	--	81	35	153	--	155	189	310	142	--	--	--	814
16S/16E-12Q1	10/4/61 92-94	1240	7.9	80	30	152	--	123	150	350	119	--	--	--	817
16S/16E-35F1	8/20/58	8929	7.7	235	144	1980	--	245	299	2490	1880	12.6	2.9	3.2	6892
16S/17E-6L1	4/30/74	--	7.2	40	--	918	65	--	1248	206	776	--	--	--	2830
16S/17E-8D1	9/10/74	--	7.7	41	1.6	723	42	--	668	225	556	--	--	3.3	2463
16S/17E-17B1	1/26/73	5940	7.5	44	3.2	1195	27	--	329	60	1710	--	1.1	4.9	3267
16S/17E-23R1	10/1/63 38-48	4450	4.3	130	6.2	736	--	--	--	4.0	1380	--	--	--	2620
16S/17E-23R1	2/24/64 155-157	2340	8.0	49	21	403	--	--	296	120	508	--	0.9	--	1270
16S/18E-2R	2/16/65 134-136	4900	7.7	127	49	860	--	--	123	412	1320	--	--	--	2860
16S/18E-6R	2/16/65 145-147	3480	7.9	94	30	574	--	--	120	275	865	--	--	--	1930
16S/18E-13R	4/22/64 145-147	1780	7.4	47	16	287	--	--	104	225	345	--	1.0	--	995

Well Number and Depth	Date and Depth Sampled	$EC \times 10^6$ at 25^oC	pH	Mineral constituents in parts per million											TDS in ppm
				Ca	Mg	Na	K	$CaCO_3$	HCO_3	SO_4	Cl	NO_3	F	B	
16S/18E-17R	2/19/64 155-157	1530	8.0	26	11	280	--	--	150	212	265	--	1.4	--	892
16S/18E-23A1	9/30/68	4390	3.9	138	31	699	--	--	--	200	893	--	1.2	--	1960
16S/18E-23A2	9/64 148-150	1570	8.2	36	16	272	4.3	--	128	224	289	3.1	1.1	0.46	929
16S/18E-23A2	9/16/64 58-60	1300	8.1	28	7.7	234	4.3	--	145	175	227	1.9	1.1	0.41	761
16S/18E-29J1	1/22/62 155-157	1450	8.3	16	7.0	282	--	153	187	180	242	--	--	--	849
16S/18E-32R2	6/30/64 140-630	1460	8.0	23	8.6	272	4.0	--	208	235	200	0.5	1.7	0.64	874
16S/18E-33R1	11/24/47 29-39	1100	--	37	17	159	--	135	165	115	179	--	0.18	--	588
16S/19E-2N1	2/3/62 134-136	1170	7.8	65	22	153	--	112	137	316	102	--	--	--	750
16S/19E-5J	5/14/63 82-84	2390	7.8	44	12	445	--	--	110	350	474	--	1.6	--	1400
16S/19E-9E	2/13/64 134-136	1670	7.8	41	6.7	278	--	--	98	208	308	--	1.3	--	912
16S/19E-15Q1	5/16/63 71-73	2390	7.5	87	31	366	--	92	112	412	438	--	--	--	1413
16S/19E-32G1	6/10/58	1090	8.0	63	31	160	12	120	146	300	160	--	0.8	--	798

Well Number and Depth	Date and Depth Sampled	$ECx10^6$ at 25^oC	pH	Mineral constituents in parts per million											TDS in ppm
				Ca	Mg	Na	K	$CaCO_3$	HCO_3	SO_4	Cl	NO_3	F	B	
16S/19E-36P1	7/6/64 100-228	1240	8.0	61	52	137	4.0	137	167	326	129	2	0.2	0.26	793
16S/20E-31K1	1/13/64	1150	7.5	80	20	146	--	123	153	312	106	--	0.3	--	755
16S/20E-32R1	2/14/41	919	7.8	31	13	137	--	111	135	102	146	1.8	--	--	497
16S/20E-32R2	7/5/62 82-84	1090	6.9	97	4.4	--	--	54	66	250	150	--	--	--	659
17S/17E-1A1	7/14/64 0-9	2160	11.0	1.2	--	451	--	551	672	175	175	--	1.1	--	1300
17S/17E-1B1	7/14/64	6440	11.5	0.8	--	1640	--	2670	3260	192	484	--	1.0	--	3860
17S/17E-1D1	7/14/64 <8	2280	5.8	134	17	315	--	10	12	438	441	--	1.1	--	1370
17S/17E-2A1	7/14/64 <11	1010	5.8	22	--	171	--	14	17	6.0	288	--	0.5	--	606
17S/17E-2B1	7/14/64 <35	792	8.5	4.2	--	160	--	103	126	7.0	174	--	0.3	--	582
17S/17E-3B1	7/14/64 19-29	970	9.6	2.6	1.8	210	--	239	291	95	94	--	0.2	--	582
17S/17E-3C1	9/2/48 0-105	1110	--	93	35	--	--	151	184	330	94	--	--	--	--
17S/17E-3C2	6/25/64 <34	724	6.6	45	4.3	80	--	9	11	26	189	--	0.3	--	434

Well Number and Depth	Date and Depth Sampled	$EC \times 10^6$ at $25^{\circ}C$	pH	Mineral constituents in parts per million											TDS in ppm
				Ca	Mg	Na	K	$CaCO_3$	HCO_3	SO_4	Cl	NO_3	F	B	
17S/18E-1B1	7/9/64 28-38	--	6.5	79	24	131	--	38	46	312	152	--	0.7	--	708
17S/18E-2B1	7/9/64 27-37	--	7.8	52	23	169	--	109	133	300	121	--	0.7	--	714
17S/18E-3B1	7/9/64 <39	--	9.0	3.8	1.6	718	--	1130	1380	190	175	--	0.6	--	1750
17S/18E-4A1	9/27/61 9-19	1190	8.1	21	8.4	226	--	131	160	215	158	--	--	--	725
17S/18E-4B1	7/9/64	1410	10.1	2.0	--	300	--	443	540	105	74	--	0.3	--	846
17S/18E-4K	11/24/47 160-175	1100	--	37	17	159	--	--	165	115	179	--	0.2	--	589
17S/18E-5B1	7/14/64 8-18	1070	7.9	15	5.5	194	--	52	63	217	144	--	0.6	--	642
17S/18E-6A1	7/14/64 <13	1780	10.0	1.4	0.1	354	--	329	401	258	124	--	0.6	--	1040
17S/18E-6B1	7/14/64 <6	3460	11.2	1.4	0.1	699	--	1150	1400	--	198	--	--	--	2080
17S/18E-6C1	7/14/64 <7	1470	8.8	2.4	2.4	296	--	121	148	288	168	--	0.7	--	882
17S/19E-1K1	7/9/64	862	8.8	35	5.5	124	--	17	21	180	123	--	0.4	--	517
17S/19E-2G1	7/9/64 30-40	966	7.2	33	7.2	153	--	33	40	258	101	--	0.6	--	580

Well Number and Depth	Date and Depth Sampled	$ECx10^6$ at 25^oC	pH	Mineral constituents in parts per million											TDS In ppm
				Ca	Mg	Na	K	$CaCO_3$	HCO_3	SO_4	Cl	NO_3	F	B	
17S/19E-3G1	7/9/64 39-49	1070	6.0	60	0.4	136	--	15	18	38	289	--	0.1	--	642
17S/19E-4G1	7/9/64 39-49	738	10.0	9.8	--	132	--	48	58	95	115	--	1.0	--	443
17S/19E-6B1	7/9/64 39-49	417	8.0	18	--	65	--	42	51	5.0	97	--	0.1	--	250
17S/20E-6R1	7/9/64	979	8.3	16	6.3	185	--	94	114	208	111	--	0.6	--	587